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# STERILIZING MILK CANS

**Reported by**

**FRANK B. LYNCH, JR.**

*Bacteriologist of Pepper Laboratory of Clinical Medicine,*
*University of Pennsylvania*

Six freshly emptied cans, numbered one to six, were washed in warm water, rinsed and allowed to drain. Into each was then placed 100 cc. of sterile, distilled water, and the can rolled and shaken to rinse the sides and bottom thoroughly. The contents were then poured into sterile bottles and each bottle numbered to correspond with the number of the can. Cultures were made in varying dilutions and the bacterial count made by the method used for estimating the bacterial content of milk.

Two cans (numbered 1 and 2) were then washed with washing powder, rinsed, sprayed with "B-K" solution, dried with steam and inverted to cool. When thoroughly dry, into each can was then placed 100 cc. sterile distilled water which was shaken around as before, and count made as before.

The remaining four cans (3, 4, 5 and 6) were likewise washed with washing powder, rinsed and steamed, all in the ordinary manner (without B-K), then drained, dried and bacteria counted, exactly as the first two cans.

*The bacterial counts of the cans were as follows:*

| | AFTER RINSING | | AFTER STERILIZATION | | |
|---|---|---|---|---|---|
| Can No. 1. | 14,640,000 | organisms | 300 | organisms | (B-K used) |
| Can No. 2. | 13,440,000 | " | 5,000 | " | (B-K used) |
| Can No. 3. | 12,544,000 | " | 5,280,000 | " | (Steam used) |
| Can No. 4. | 5,760,000 | " | 2,968,000 | " | (Steam used) |
| Can No. 5. | 24,960,000 | " | 22,640,000 | " | (Steam used) |
| Can No. 6. | 10,160,000 | " | 2,272,000 | " | (Steam used) |

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## GENERAL LABORATORIES

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# THE INFLUENCE OF CALCIUM AND PHOSPHORUS IN THE FEED ON THE MILK YIELD OF DAIRY COWS

EDWARD B. MEIGS AND T. E. WOODWARD

*From the Research Laboratories of the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.*

Opportunities for observing the effects of food on milk secretion have been rather favorable on the United States Experimental Farm at Beltsville, Maryland, where the authors are stationed. There has been maintained here since 1912 a herd of from 50 to 100 cows, some of which are pure bred Guernseys, Jerseys, and Holsteins; and some, grades. Daily records have been kept of the milk yields throughout, and yearly records of the amounts of food consumed up to 1918. Since 1918, monthly or daily records of the rations have been kept. The fat has been determined in the milk of each cow once a month, and from the results so obtained the monthly and yearly yields of fat have been calculated. The foods chiefly used have been corn meal, wheat bran, cottonseed meal, linseed meal; alfalfa and other legume hays; and corn silage and stover. Most of the cows have had a little pasture in the summer, but not enough to make up any considerable proportion of the total amount of food eaten in the year.

The aim has been to feed the cows as much protein as is required by the most liberal of the American feeding standards, to keep them in good condition, to have them calve once a year, and to have them dry for six or eight weeks each year before calving. It has generally happened in practice that the cows were fed a little less liberally than is demanded by the Savage and Eckles standards (1) for the first two or three months after calving, and a little more liberally later. When they were dry, they were usually fed 4 pounds of grain B,[1] 4 pounds of legume hay, and as much silage as they would clean up. When the hay

[1] See table 1, Grain mixtures used in experiments.

was alfalfa, and the amount of silage eaten daily 30 pounds, which was the most usual state of things, this ration provided 1.29 pounds of digestible crude protein and 10.29 pounds of total digestible nutriment daily. After subtracting the maintenance requirement for a 1000-pound cow, this would allow 0.59 pound protein and 2.37 pounds total nutriment daily for the growth of the unborn calf, which, according to the results obtained by Eckles (2), ought to be sufficient.

We have recently calculated the protein and total nutriment in the yearly rations of a number of cows from the general herd and have compared these quantities with those required for their maintenance and for their milk and fat yield according to the Savage standard. The results have shown that the cows usually received rations a little more liberal than those demanded by this standard.

During the last two years a number of the pure bred Holsteins have been run on official test. In order to increase their milk yield, their rations were made decidedly more liberal than those called for by any of the feeding standards. During the time that they were milking they received daily about 12 pounds of alfalfa hay, 20 pounds of corn silage, and as much grain as they could clean up without getting sick; they usually ate 18 to 20 pounds a day of grain F. They were fed heavily also before their calves were born. For sixty days or more before calving they usually received about 15 pounds of grain F, 12 pounds of alfalfa hay and 25 pounds of corn silage. This ration contains approximately 4 times as much protein and two and one-half times as much total nutriment as the routine ration fed to the dry cows of the general herd.

The test cows gave from 15,000 to 20,000 pounds of milk in the year, that is, three to four times as much as most of the cows in the general herd. A part of this larger yield is due to the fact that the test cows were better bred, but a part is also due to the larger quantity of feed that they obtained. How much of the increased milk yield ought to be attributed to each of these factors is a question of great practical interest.

The cycle of lactation consists of two phases which may be called the preparatory and the active phases. Considerable changes go on in the udder of a cow for some time before her calf is born, and usually make themselves manifest by an increase in size and congestion of the organ. There is no doubt that the amount of the subsequent milk yield is largely dependent on these changes, and it is highly probable that the changes themselves are dependent on the state of nutrition in which the animal happens to be for the few weeks before her calf is born.

It is well known that animals are capable of storing up large quantities of nutritive material in their bodies in times of plenty and using these stores in times of stress. The effect of food on milk secretion may, therefore, often be long delayed and rather complicated. It is not at all impossible that the effects of a deficient ration supplied in one lactation period may not show themselves until the subsequent period or even later.

Figures 1 and 2 give graphically the histories of two cows which were brought to the Beltsville farm some years ago, and fed and treated according to the usual routine. The milk yields fell off very noticeably during the routine treatment. After several years of the routine treatment, no. 17 was given an unusually long dry period before calving, and no. 201 a more liberal ration for some weeks before calving. In both cases the subsequent milk yields were markedly increased.

The increases in the milk yields are to be attributed in the one case to the more liberal ration supplied before the calf was born; and in the other case to the long dry period with a super-maintenance ration. The rations fed after calving bore about the same relation to the milk yields as they had in previous years. It may be added that the milk yield for the first few weeks of lactation is not very closely dependent on the contemporaneous food supply (10).

The course of events illustrated by the cases of cows 17 and 201 is not exceptional, but typical. Several other similar histories could be presented. Indeed, it has been the regular rule on this farm that greatly increased milk yields were obtained when cows from the general herd were dried off two months or

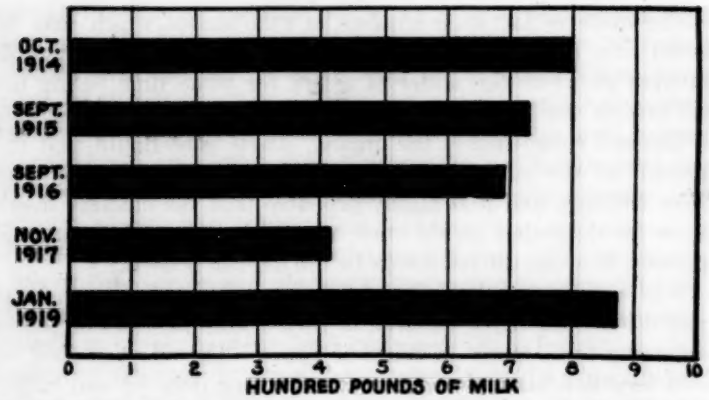


FIG 1. THE INFLUENCE ON THE LENGTH OF THE DRY PERIOD ON THE SUBSEQUENT MILK YIELD IN THE CASE OF COW 17

The columns represent the pounds of milk given in the first clear calendar month after calving in the years indicated. Before calving in the years 1914 to 1917 inclusive, this animal was fed the routine ration devised for the dry cows at Beltsville; her dry periods averaged 44 days. Before calving in December, 1918, she was given a dry period of 122 days and fed approximately as in her previous dry periods. See p. 199.

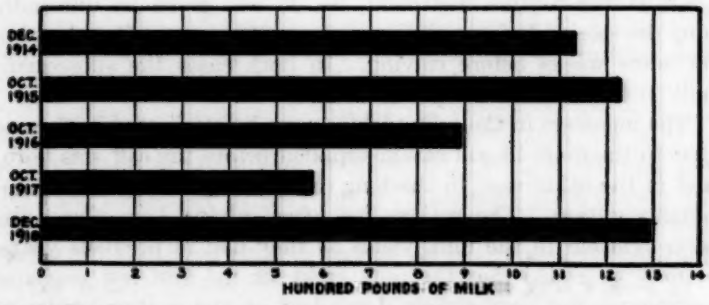


FIG. 2. THE INFLUENCE OF THE LENGTH OF THE DRY PERIOD AND OF THE RATION FED DURING THAT PERIOD ON THE SUBSEQUENT MILK YIELD IN THE CASE OF COW 201

The columns represent the pounds of milk given in the first clear calendar month after calving in the years indicated. Before calving in the years 1914 to 1917 inclusive, this animal was fed the routine ration devised for the dry cows at Beltsville; her dry periods averaged 50 days. Before calving in December, 1918, she was given a dry period of 78 days, and during the last 40 days of this period was fed a much more liberal ration than the previous one. See p. 201.

more before they were due to calve, and fed liberally during this period. Cows 17 and 201 were selected as examples, not because the downhill course of the milk yields on the routine treatment were particularly rapid; or the subsequent recoveries, particularly marked; but simply because they have been freer from disease and from disturbing experiments during their stay at Beltsville than the other examples which might have been selected. It is, therefore, a very moderate statement of the case to say that average and high producing cows are often,[1] not kept up to anything like their optimum milk yield when they are bred to calve once a year and fed for several years approximately according to the most liberal of the American feeding standards, even though they may get a little pasture in addition. Under this treatment the milk yield may often be reduced, after a few years, to less than half the optimum; and, after it has been so reduced, it may be very greatly increased by liberal feeding during a two months' dry period. A point of great interest to be noted in the history of cow 201 is the length of time which it took for the full effects of the routine method of feeding to become apparent. The milk yield did not reach its lowest point until she had been on the farm for four years.

## THE NATURE OF THE DEFICIENCY IN THE ROUTINE RATIONS FED AT BELTSVILLE

It is not improbable that the rations fed at Beltsville were not generally deficient, but deficient only in one or a few particular constituents necessary for milk secretion. The cows were kept in good general condition, which seems to indicate that they received enough of the energy yielding portion of the ration. The recent very interesting work of Forbes (3) indicates that liberally milking cows may often receive insufficient calcium and phosphorus in their rations; the further experiments which we

[1] Our evidence shows only that cows are not kept up to their optimum milk yield when fed the protein and total nutriment required by the standards in the form of the amounts of grain, hay, and silage used on the Beltsville farm. The reader must judge for himself how closely this method of feeding approaches what is typical throughout the country.

have to report were directed toward throwing more light on this question.

There is little doubt that a cow's milk yield is markedly influenced by the nutriment which she receives during the six or eight weeks before her calf is born. The experiments to be reported have, therefore, been confined to the influence of the ration fed during this period on the subsequent milk yield; and, for the reasons given below, the phosphorus fed during the dry period has been varied rather than the calcium.

The results of certain metabolism experiments in which the calcium and phosphorus balances have been followed—particularly those of Forbes (3) and Hart (4)—seem to show that calcium and phosphorus metabolism are largely independent of each other. But in these experiments the calcium and phosphorus balances have not been followed for more than twenty days successively. There is no reason to doubt the figures that have actually been obtained, and it is very likely that a cow may lose 200 or 300 grams of calcium while remaining in phosphorus equilibrium. But it is doubtful whether the metabolic independence of the two elements ever goes much further than this. In a recently published article this question has been discussed in some detail, and it has been pointed out that the weight of evidence obtained from carcase analyses is strongly against the view either that the ratio Ca: P in bone is subject to more than very small variations or that the concentration of either of these elements contained in any of the soft tissues undergoes more than insignificant changes. Evidence was also adduced to indicate that calcium assimilation in cows is likely to be seriously interfered with for a period of at least eight days by the mere collection of their urine and feces by attendants as practiced in the experiments of Forbes, of Hart, and of ourselves (5).

It is likely, therefore, that any considerable deficiency of either calcium or phosphorus in the rations of a milking cow will bring about the loss of both elements from the animals' bones if continued for more than two or three weeks, and that a cow which has suffered from the lack of either during any considerable part of her lactation period will find herself depleted in both when she reaches the end of that period.

In recently published articles from this laboratory (6) it has been shown that the phosphorus content of the blood plasma of cows is highly variable, and that it is likely to be low in the plasma of the Beltsville cows toward the end of their periods of pregnancy. This suggests that the cows of the Beltsville herd usually reach the end of their lactation periods with their phosphorus stores depleted, and that the rations fed during the dry period are not sufficient to restore them. For the reasons which have been given above, it is likely that the calcium stores of the Beltsville cows are also depleted during their lactation periods; and that neither the calcium nor the phosphorus stores can be restored to their proper level during the dry period, unless the cows are fed rations which make it possible for them to assimilate liberal quantities of both elements.

In the articles from this laboratory above referred to, certain other facts regarding calcium and phosphorus metabolism were brought to light. It was shown that the concentration of calcium in cows' blood plasma is much more constant than that of phosphorus. It is usually easy to raise the concentration of plasma phosphorus by increasing the amount of phosphorus in the rations —either by feeding more grain or by adding sodium phosphate to the ration. But the changes brought about in the concentration of plasma calcium by analogous procedures, or by any other influences that we have encountered so far, are comparatively insignificant, and usually fall within the limits of error of our determinations.

It has seemed likely, therefore, that changing the amount of phosphorus in the ration would have more immediate and easily determinable effects on the changes which go on in a cow's udder shortly before her calf is born, than changing the amount of calcium. The experiments to be reported were planned with this idea in mind. But it was essential that both the control and the experimental animals should have plenty of calcium in their rations and they, therefore, all received alfalfa hay in quantities which it was hoped would provide sufficient calcium for their needs. The details of the experimental procedure and the results obtained are given in the description and tables at the end of the article.

The experiments consisted essentially in drying cows off about sixty days before they were due to calve; in feeding some of them (the controls) a certain basal ration; in feeding the others (the experiments) the same basal ration, but with the grain and hay fed on alternate days[3] and with sodium phosphate added to the grain; and in following the milk yields from the tenth to the fortieth day after calving.

Some of the animals used in the experiments were from the general herd, and had previously been fed approximately according to the Savage feeding standard. Others had been on test during the year preceding the experiments, and had been fed much more liberally. In the case of the animals from the general herd (tables 2 and 3) the alternated feeding with phosphate had a very favorable influence on the subsequent milk yield; in the case of those which had been on test (table 4), the effect was insignificant. This indicates that the rations fed to the general herd were deficient in one or both of the principal bone-building elements.

The results show that the effect of the alternated feeding with phosphate on the subsequent milk yield will depend on the previous history of the cows studied as well as on the amount of phosphorus contained in the basal ration. It follows that the quantitative results of the experiments are significant only for the special conditions under which they were carried out. They might be entirely different in a herd whose previous history had been different, or with a basal ration which contained a different amount of phosphorus.

The attempt has been made, however, to get an approximately quantitative idea of the increase in milk yield produced by the phosphate feeding under the conditions of experimentation used with the cows of the general herd. For this purpose only those animals have been considered which figure both as controls and experiments, and whose histories are given in table 2. The method and results used in this attempt are given in table 9 with its appended comment and in figure 3. The animals gave,

[3] See description of experiments, p. 203.

on the average, 37.9 per cent more milk after the phosphate feeding than would have been expected from their previous performance.

The milk yield from the tenth to the fortieth day after calving has been taken as the most important measure of the effects produced by the alternated feeding with phosphate during the

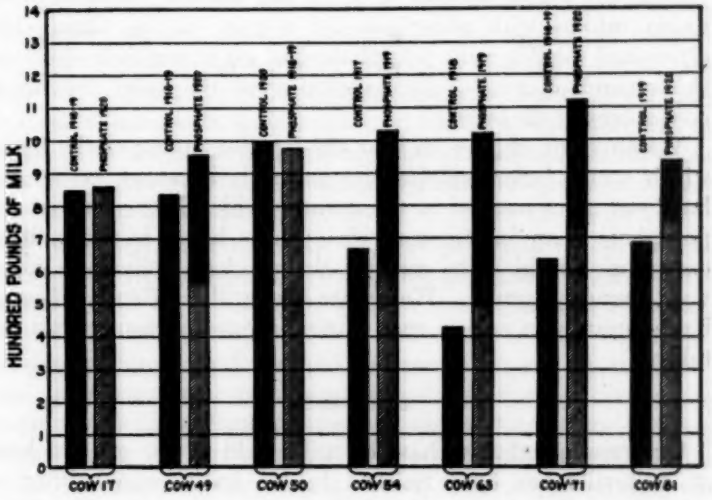


FIG. 3. COMPARISON OF MILK YIELDS OF GRADE COWS FROM THE GENERAL HERD AFTER CONTROL AND PHOSPHATE FEEDING

The columns show the amounts of milk given in 30 days soon after calving; the lighter portions of the columns show the amounts of milk to be expected after the phosphate feeding, using the yields after the control feeding as a basis, and taking into account the facts that the animals were generally older during the experimental feeding, and that some of them aborted. See pp. 208–210 and p. 215.

preceding dry period. But certain other aspects of the effects produced by this treatment have also been studied.

Both the animals on the experimental feeding and those used as controls were weighed from time to time. We do not wish to lay too much stress on the results obtained, because the manner in which an animal gains weight in the period of a month or so before it calves depends almost as much on its previous

history as on the ration fed at the time. The results in question are given in the description of the experiments, pp. 212 to 215, and in tables 5, 6, 7, and 8. They are rather irregular, but indicate, on the whole, that the animals on alternated feeding with phosphate made somewhat better gains than the controls.

In a previous publication from this laboratory (5), a balance experiment was described in which the animals received alternated rations with phosphate for a part of the time. The alternated feeding with phosphate had no perceptible effect on the amount of urine or feces voided or on the water content or consistency of the feces.

We have the impression that the increase in size of the udder which occurs before calving has generally appeared earlier and has been more marked in the animals which have received the phosphate than in the controls. There have, however, been exceptions to this rule, and we do not feel inclined to insist very strongly upon it. We realize keenly the difficulty of judging accurately in such a case where no exact measurements are taken.

## DISCUSSION

Our results indicate that the milk yield of the general herd at Beltsville has been reduced by an insufficiency either of calcium, of phosphorus, or of both in the rations, in spite of the facts that these contained more than the average proportions of both calcium and phosphorus and were fed in the amounts required according to the feeding standards. We think it is still an open question whether calcium or phosphorus has been the element chiefly lacking, and whether the rations could be improved from the standpoint of mineral nutrition by varying the proportions of the different feeds used. Work aimed to throw light on these problems is now being carried out here. In the mean time, however, it seems worth while to consider the results in so far as they indicate what ought to be done with the knowledge already at hand.

Table 2 contains the cases where a cow's record after the phosphate feeding is compared with a previous record of her

own made after a period on the basal ration. It will be noted that in most of these cases the basal ration was fed before the first calf was born. The results as given in this particular table, therefore, are chiefly evidence for the view that the heifers received insufficient calcium or phosphorus in the rations supplied to them before they had their first calves.

We believe that this was the case and we shall later discuss the rations supplied to the heifers which had never had calves. But the records for the general herd indicate that, under the Beltsville routine, the animals never recovered from the mineral shortage which made itself evident in the first lactation period.

The evidence from the records which indicates this may be summed up as follows: In the case of the animals born at Beltsville and kept under the routine treatment there was no tendency for the milk yield to rise after the first lactation period to the extent that it did in the cases of nos. 54, 63, 71 and 81, shown in table 2. The rise as between the first and subsequent lactation periods was approximately that which would be expected from the data collected by Pearl and Patterson (7), and by the Holstein and Guernsey breeding associations. In the case of animals brought to the farm from other places and kept under the routine treatment, there was frequently a tendency for the milk yield to fall off more rapidly than it should with advancing age, as in the cases of cows 17 and 201, figures 1 and 2.

As many of the cows which received the alternated rations with phosphate received a basal ration somewhat lower than that fed to the general herd during their dry periods, it is not unfair to compare the milk yields of these two sets of animals. Cows 49, 54, 71 and 81 may be taken as representing the effects of the phosphate feeding in the case of grade Guernseys. In a period of thirty days soon after calving, these animals gave 1009 pounds of milk on the average. Their records may be compared with those of the other grade Guernseys of the herd, selecting lactation periods later than the first and in which there was no suspicion of abortion or other disturbing disease, and using the best month's milk yield in each lactation period as the figure to be compared with that given above. There are four

animals with a total of eight lactation periods available for the comparison, and the average best month's milk in the eight lactation periods was 660 pounds. As the grade Guernseys available for this comparison were rather few, the same calculation was made for the grade Jerseys. There are 16 animals with 52 lactation periods available in this case. The average best month's milk is 722 pounds. The grade Holsteins are not sufficiently numerous to give figures of any value.

No cow among the grade Jerseys and Guernseys of the general herd has ever surpassed the thirty day record of cow 71. In only one case has the average thirty day record given for cows 49, 54, 71 and 81 after the phosphate feeding, been surpassed, namely, with a best month's milk yield of 1041 pounds given by one of the grade Jerseys. In only five cases has the lowest thirty-day record among these four cows been surpassed, namely, by best month's milk yields of 1041, 988, 987, 1004 and 943 pounds respectively.

The results show, therefore, that the cows of the general herd at Beltsville suffered from an insufficiency of either calcium or phosphorus or both in their rations throughout their lives, both before their first calves were born and afterward. The following shows how they were fed, a little more in detail than has been done heretofore.

The young stock generally received milk until they were six months old or more. The feeding of grain, hay and silage, however, was started before the end of the first month and gradually increasing quantities of these foods were given until, at the end of six months the calves were taking 3 pounds of grain, 3 pounds of legume hay and 10 to 20 pounds of corn silage. After they were taken off milk, the calves were usually fed 3 pounds of grain, 3 pounds of legume hay and as much corn silage as they would clean up. The grain most used was grain E (see table 1). If they ate 25 pounds of corn silage daily which may be taken as a fair average, this ration would supply 0.94 pound digestible protein daily and 8.16 pounds total digestible nutriment. This is approximately the protein requirement given in the Wolff-Lehmann feeding standards for growing dairy cattle, and somewhat more than the requirement for total nutriment (8).

The manner in which the cows were fed and treated after their first calves were born, and subsequently, has already been discussed at some length (pp. 185 to 186). It is only necessary to add a word about the actual amounts of grain, hay and silage given. The manner in which the mature dry cows were fed has already been given (p. 185). The mature milking cows were generally fed 1 pound of grain B or C, to 3 pounds of milk, 6 or 8 pounds of legume hay, and as much corn silage as they would clean up. They usually gave about 25 pounds of milk a day when they were fresh, and, at this period they commonly got 8 pounds of grain B, 8 pounds of legume hay and 30 pounds of corn silage. They usually got a little thin with the progress of their lactation, and were then fed somewhat more grain in proportion to the milk yield. In the course of the year, as has already been stated, they got a little more protein and total nutriment than is required by the Eckles or Savage feeding standards.

The bone-building elements can probably be supplied in sufficient quantity in two different ways—either by feeding the ordinary materials much more liberally than the feeding standards require or by adding calcium and phosphorus in the form of inorganic salts directly to the rations. We have entire confidence that the latter method will finally be adopted and will effect a great saving in the cost of producing milk.

But so radical a change in feeding practice ought perhaps to be introduced slowly and with caution; the more conservative dairymen will probably prefer to keep to the ordinary farm feeds until the effects of feeding inorganic salts of calcium and phosphorus have been more fully worked out by the experiment stations.

Our experience at Beltsville indicates that with many cows a liberal ration fed for four to six weeks before calving easily pays for itself through the increased flow of milk in the subsequent lactation period, and we think that there are many cows throughout the country which are far more valuable than their owners suppose them to be. Those dairymen who have been feeding their animals according to the standards or less, should try out

their herds by giving each cow a period of two months dry and feeding her during that period three or four times the protein and two or three times the total nutriment required for maintenance, using feeds which contain plenty of calcium and phosphorus—legume hay and a liberal proportion of bran and cottonseed or linseed meal. If they find that the milk yield of any of their cows is doubled by this process, they will run no risk of reducing their profits by feeding those cows even 50 per cent more nutriment in the course of the year than the feeding standards call for.[4]

There is one other aspect of the case which must be discussed. Quite apart from the question of the feed cost per pound of milk when a cow's yield is reduced by feeding her a ration deficient in one or more necessary constituents is the question of the effect of this process on her capacity to resist disease. The Beltsville herd has suffered severely in the last three years from contagious abortion. The relation between the incidence of this disease and the manner in which the cows have been fed is being carefully studied at present, and the results of this study will be reported later. The results already obtained, however, are sufficient to justify a strong suspicion that abortion has occurred more frequently among the animals that were less adequately fed. But, whatever the final results of this study may be, it is obviously bad practice to allow a cow to deplete her body stores of important materials for long periods of time, even though milk may thereby be temporarily more economically produced. The ideal method is clearly to keep the yearly supply of raw materials in the food equal to the demand for milk production.

[4] Feeding cows heavily before they calve, of course, introduces the risk of milk fever. But if this disease is properly treated, the mortality is not high, and there are no enduring bad effects. A well run dairy should be equipped for dealing with milk fever. Our experience at Beltsville shows that the risk even of the appearance of the disease is not very great. In the last five years there have been something over 30 cases of cows fed two to four times the maintenance requirement of protein and total nutriment before they calved, and milk fever has appeared only twice. One of these cases was in a young cow, but was mild; the other was in a cow 15 years old.

SUMMARY

1. Feeding cows for several years according to the commonly accepted standards with little or no additional pasture, may result in their milk yield being reduced much below the optimum. The condition of reduced milk yield so brought about may be corrected by giving the animal a dry period of two months, and feeding during that period a ration containing legume hay and grain with a high phosphorus content and with three or four times the amount of protein required for maintenance, and two or three times the total nutriment. The milk yield in the subsequent lactation period may sometimes be doubled by this treatment.

2. In the case of cows of which the milk yield has been reduced by several years' standard feeding, a greatly increased yield can be brought about by feeding "alternated rations with phosphate" during the dry period. This is taken to mean that the ordinary rations are more likely to be deficient in one or both of the principal bone-building elements than in any other constituent.

In conclusion we wish to acknowledge the valuable services of Messrs. H. J. Nedrow, H. T. Converse, and W. E. Benscoter. Messrs. Nedrow and Converse were the herdsmen at the Beltsville farm during the period when the experiments were carried out and supervised the feeding and care of the experimental animals. Mr. Benscoter was responsible for the feeding in a number of cases, and carried out this part of the work with unusual care and accuracy.

## DESCRIPTION OF EXPERIMENTS

### *Results showing the effects on milk yield of liberal feeding during the dry period*

*Cow 17.* This animal was a grade Jersey born in 1909 and brought to Beltsville in 1912. The protein and total nutriment contained in her rations during the years 1914, 1915, 1916 and 1917 were calculated and compared with the quantities required for her maintenance and for her milk and fat yield according to the Savage standard (9), and it was found that she received on the average a surplus of about 10 per

cent of protein and of about 2 per cent total nutriment. It may be considered, therefore, that she was fed as nearly according to this

TABLE I

*Grain mixtures used in experiments**

| GRAIN A | | GRAIN B | |
|---|---|---|---|
| | *pounds* | | *pounds* |
| Corn meal | 45 | Corn meal | 40 |
| Wheat bran | 36 | Wheat bran | 40 |
| Cottonseed meal | 18 | Cottonseed meal | 20 |
| NaCl | 1 | NaCl | 1 |
| **GRAIN C** | | **GRAIN CP** | |
| Corn and cob meal | 45 | Grain C | 100 |
| Wheat bran | 36 | $Na_2HPO_4.12H_2O$ | 11 |
| Cottonseed meal | 18 | | |
| NaCl | 1 | | |
| **GRAIN CP1** | | **GRAIN CP2** | |
| Grain C | 100 | Grain C | 100 |
| $Na_2HPO_4.12H_2O$ | 10 | $Na_2HPO_4.12H_2O$ | 6 |
| **GRAIN D** | | **GRAIN DP** | |
| Hominy grits | 45 | Grain D | 100 |
| Ground oats | 36 | $Na_2HPO_4.12H_2O$ | 19 |
| Cottonseed meal | 18 | | |
| NaCl | 1 | | |
| **GRAIN E** | | **GRAIN F** | |
| Corn and cob meal | 55 | Ground oats | 28 |
| Wheat bran | 30 | Linseed meal | 20 |
| Linseed meal | 15 | Cottonseed meal | 10 |
| NaCl | 1 | Gluten feed | 14 |
| | | Hominy feed | 14 |
| | | Wheat bran | 14 |
| | | NaCl | 1 |

* The cottonseed and linseed meal used in these mixtures were meals from which the fat had been extracted by the old process: heat and pressure without solvents.

standard as is possible under any ordinary conditions. She was on pasture for only 7 days during the four years under consideration.

She had a calf toward the end of the summer of each year; the 1917 calf was born six weeks ahead of time, but it survived, and is still alive and well (June, 1920). The other three calves were all born normally. Her dry periods were 44 days on the average.

In 1914, she gave 5709 pounds of milk; in 1915, 5121 pounds; in 1916, 5056 pounds; in 1917, 4693 pounds; and in 1918, 2569 pounds.[5] In 1918, she was given a dry period of 122 days, with approximately the same ration as in previous dry periods. She calved December 11, 1918, and her milk yield for 1919 rose to 5578 pounds.

During her dry periods in 1914, 1915 and 1917, she was fed 4 pounds of grain B, 4 pounds of legume hay, and 30 to 35 pounds of corn silage. During her dry period in 1916, she received 4 pounds of grain B, 3 pounds of oat hay, 28 pounds of corn silage, and had 7 days on pasture. During the last 53 days of her 1918 dry period she was fed 4 pounds of grain C, 4 pounds of legume hay, and 30 pounds of corn silage. Her milk yields in pounds for the first clear month after calving in each of the five years under consideration were as follows:

| | *pounds* |
|---|---|
| October, 1914 | 799 |
| September, 1915 | 731 |
| September, 1916 | 690 |
| November, 1917 | 416 |
| January, 1919 | 873 |

The milk yield for the first six weeks after calving is not markedly influenced by moderate changes in the contemporaneous food supply (10), and the rations given in the months mentioned above were so nearly equivalent that they could not have produced the observed differences in the milk yield. These are to be attributed, therefore, to the nutritive condition of the cow in her dry periods. The large yield for January, 1919, is the result of the long dry period with a ration considerably above the maintenance requirement.

*Cow 201.* This animal was a pure bred Holstein, born March 13, 1905, and brought to Beltsville in 1912. The protein and total nutriment contained in her rations during the years 1914, 1915, 1916 and 1917, were calculated and compared with the quantities required for her maintenance and for her milk and fat yield according to the Savage standard, and it was found that she received, on the average, a surplus of about 8 per cent protein and of about 9 per cent total nutriment.

[5] This very low yield is partly explained by the facts that the cow aborted in 1917, and that she had an unusually long dry period in 1918.

She was on pasture for 46 days during the four years under consideration. She calved normally in the autumn of each year. Her dry periods were 50 days on the average.

In 1914, she gave 12182 pounds of milk; in 1915, 8269 pounds; in 1916, 7224 pounds; in 1917, 5708 pounds; and in 1918, 4796 pounds. In 1918, she was given a dry period of 78 days, and, during the last 40 days of this period, was fed a much more liberal ration than during her previous dry periods. She calved October 30, 1918, and her milk yield for 1919 rose to 8711 pounds.

During her dry periods in 1914, 1915, 1916, and 1917, she was fed approximately the same rations as those fed to cow 17 in her corresponding dry periods. During the last 40 days of her 1918 dry period, she was fed daily 11 pounds of grain C, 11 pounds alfalfa hay, and 26 pounds corn silage. Her milk yields in pounds for the first clear month after calving in each of the five years under consideration, were as follows:

| | pounds |
|---|---|
| December, 1914 | 1138 |
| October, 1915 | 1230 |
| October, 1916 | 896 |
| October, 1917 | 579 |
| December, 1918 | 1293 |

For the same reasons as have been given in the case of cow 17, the greatly increased milk yield after the 1918 calving is to be attributed to the more liberal ration fed in the 1918 dry period. It should perhaps be mentioned that this cow was milked three times a day during December, 1918, and only twice in the other months above recorded. But the increase in milk yield to be expected from this change in treatment has been much studied at Beltsville; it could hardly have been more than 10 per cent in such a case as that under consideration. The actual increase as between October, 1917, and December, 1918, was more than 120 per cent.

### *Experiments showing the effects on milk yield of feeding phosphate with alternated rations during the dry period*

The experiments may be briefly described as follows. Cows were dried off about two months before they were due to calve, and were fed, during their dry periods, a basal ration containing 3 to 6 pounds of grain, 4 to 5 pounds of alfalfa hay, and 30 pounds of corn silage. Half of the animals were used as controls and were fed the basal rations

without supplement. The other animals received the same basal rations as the controls, but supplemented with a certain amount of sodium phosphate, and with the grain and hay of the rations fed on alternate days. In many cases the same animal served as a control one year and as an experiment the next year. In a typical experiment an animal would receive daily for 60 days before calving three pounds of grain C (see table 1), 4 pounds of alfalfa hay, and 30 pounds corn silage. The next year, she would receive in the corresponding period the same average daily quantities of the same foods; but instead of receiving equal amounts of all the foods every day, she would receive on one day no grain, 8 pounds of alfalfa hay, and 30 pounds corn silage. The next day she would receive 6 pounds of grain with sodium phosphate added to it, no hay, and 30 pounds of corn silage. For the sake of brevity, the first procedure will be spoken of as the "control feeding;" the second, as the "experimental feeding" or as the "alternated feeding with phosphate."

The animals which received the phosphate were fed alternated rations, as above described, with the idea of separating, to some extent, the calcium and phosphorus compounds in the intestinal tract. There is a good deal of evidence to show that the absorption of phosphorus from the intestinal tract may be hindered by the simultaneous presence of calcium compounds (11). As the hay contains most of the calcium of the rations, and the grain, most of the phosphorus, the experimental animals received an excess of calcium one day and an excess of phosphorus the next. When the average daily ration was 3 pounds grain CP, 4 pounds alfalfa hay, and 30 pounds corn silage, they received about 61 grams Ca and 17 grams P on the days when they were fed hay; and, about 16 grams Ca and 50 grams P on the grain days.

After calving the controls and experiments were fed alike or according to their milk yields. As the milk yield for the first five or six weeks after calving is not much influenced by small changes in the contemporaneous food supply (10), we have not thought it necessary to give a detailed account of how the cows were fed during this period.

The milk and fat yields of the control and experimental animals were followed for the first 40 days after calving, and, as a rule, the milk produced from the tenth to the fortieth day after calving was taken as a measure of the effect of the alternated feeding with phosphate. In many cases the body weights of the animals were followed during the periods when they were on the control or the experimental feeding.

It was decided to use sodium phosphate as the mineral supplement, partly in order to study the effects of phosphorus as distinguished from calcium, partly because the phosphates of sodium are much more soluble in neutral solutions than any of the phophates of calcium, and it was judged that feeding the more soluble salts would produce the maximum effect of the phosphorus on metabolism. Di-sodium phosphate ($Na_2HPO_4$) was selected, because it is the most nearly neutral of the various sodium salts. A very pure preparation of this compound, containing 9 to 12 molecules of water of crystallization,[6] can be obtained commercially at about $100 per ton.

Sodium phosphate has been fed in only a few of the numerous phosphate feeding experiments which have been carried out in the past. Gouin and Andouard (12) worked with it to some extent, but they give no information in regard to the particular sodium phosphate used or in regard to its water content. If we understand them right, their doses were very small in comparison to those which we finally used. We began with doses of 4.5 grams P as $Na_2HPO_4$ daily, and finally got up to doses of 24 grams without producing any noticeable digestive disturbances whatever.

In deciding on the basal ration to which the phosphate was to be added we were largely influenced by the fact that the dry cows at Beltsville had previously been fed as a matter of routine, a ration consisting of 4 pounds grain,[7] 4 pounds of legume hay, and 30 pounds of corn silage.

This ration carries decidedly more than enough protein and total nutriment to provide for the maintenance of a 1000 pound cow, according to the Haecker and Savage Standards; (9) and according to the results obtained by Eckles (2), the surplus should be sufficient to provide for the development of the unborn calf. Using a slightly less liberal feed for the basal ration made it possible to compare the performance of the cows fed phosphate in addition with that of the general herd. In several cases, however, a somewhat more liberal ration was used both for the control and for the experimental animals.

[6] The salt crystallizes with 12 molecules of water, but loses a considerable part of its water of crystallization readily on exposure to air. As obtained commercially, therefore, it generally contains less than 12 molecules of water.

[7] The grain mixture fed has been varied from time to time. Those most frequently used were grains B and C. The protein, total nutriment, and mineral content of these are fairly typical for all the other mixtures.

Alfalfa was selected as the hay to be used, partly on account of its high calcium content, and partly because it had been used at Beltsville in the past as often as anything else.

The experiments fall into two general classes: first, those on animals which had been fed for some years previously according to the routine used for the general herd; and, second, those on animals which had been on test, and which, for at least a year preceding our experiments had been fed much more liberally than the general herd. In the first class there are two smaller groups. Group 1 consists of seven experiments where the same animal served in one year as control; and in another, as experiment. Group 2 consists of experiments in which the records of animals on the phosphate feeding were compared with those of other approximately similar animals used as controls.

The data in the case of the animals which had been on test are rather complicated. In our experiments all these animals were dried off 60 days or more before they were due to calve, and were fed during this period on a basal ration of 3 pounds grain D, 5 pounds alfalfa hay, and 30 to 35 pounds corn silage. The controls received this ration fed in the usual way and without any supplement. The others received grain and hay on alternate days and with phosphate added to the grain. It would be possible to compare the experiments directly with the controls in this series, but as the animals are not exactly comparable, and, as the cases are few, we have thought it better to take into account the past records of both controls and experimental animals. We have, therefore, compared the performance of each animal after either control or phosphate feeding with her performance in the preceding year, and determined whether the phosphate or control performances compare more favorably with the preceding performance of the same animal.

For several years before the experiments began, the cows from the general herd, of which the histories are tabulated in tables 2 and 3 were fed approximately according to the Savage standard. They received, on the average, about 0.25 pound protein and 1 pound total nutrient more daily than this standard calls for. The building of the annual calf is not taken account of in this calculation, but the yearly 91 pounds of protein and 365 pounds total nutriment received over and above what the standard calls for should have provided sufficiently for this process, according to Eckles's (2) results.

The manner in which the test cows were fed contrasts strongly with the above picture. During the year that they were on test and actually milking, these animals received a daily average surplus of 1 to 1.5

pounds protein and about 4 pounds total nutriment. For a number of weeks before they calved, they received the enormous daily surplus of about 4 pounds protein and 16 pounds total nutriment. In other words, the ration fed before calving in preparation for the test contained about 6 times as much protein and about 3 times as much total nutriment as is required for maintenance. In the course of a year, taking into account the dry period before going on test, those animals received about 100 per cent more protein and about 50 per cent more total nutriment than is called for by the Savage standard.

It will be noted that the character of the experiments has made it necessary to keep the animals under observation for periods of more than a year, and to use the milk yield as a measure of the results to be studied. In the course of a year, innumerable small things, which are quite beyond experimental control, but which might have some influence on milk yield, necessarily happen to a cow—weather changes and small disturbances in health and appetite may be mentioned as examples of such incidents. To report them, even to the extent to which they have been recorded in our notes, would be quite impracticable on account of the space required. In the following description, therefore, there are given only such features of the histories of the cows as might have an influence on the milk yield of the same general order of magnitude as the differences which have commonly been observed as the result of the phosphate feeding.

The immediately following paragraphs give in detail the manner in which the animals were fed before calving in our experiments, and tables 2, 3, and 4 give such data regarding the experiments as can be conveniently tabulated.

### *Rations received before calving by animals used in the experiments*

#### Animals from the general herd

*Cow 17, 1918.* September 25 to October 18, 3 pounds grain C (see table 1), 4 pounds alfalfa hay, 30 pounds corn silage. October 19 to December 11, 4 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 17, 1919–20.* November 26, 1919, to February 14, 1920, alternated rations with daily average of 3¼ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage. February 15 to March 29, 1920, alternated rations with daily average of 4¼ pounds grain CP, 4 pounds alfalfa, hay, 30 pounds corn silage.

*Cow 21, 1918.* August 28 to November 30 alternated rations with daily average of 6 pounds grain $CP_1$, 5 pounds alfalfa hay, 30 pounds corn silage.

*Cow 49, 1918.* October 31 to December 1, 4 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage. December 2 to 25, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 49, 1919–20.* December 12, 1919 to January 14, 1920, alternated rations with daily average of 4¼ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 50, 1918.* October 2 to December 20, alternated rations with daily average of 5 pounds grain $CP_1$, 4 pounds alfalfa hay, and 30 pounds corn silage. From October 4 to 9, 85 grams $CaCO_3$ were added daily to the silage on the days when hay was fed; from October 10 to December 20, 158 grams.

*Cow 50, 1920.* April 2 to June 3, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 54, 1917.* March 14 to May 14, 3 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 54, 1919.* May 8 to June 2, alternated rations with daily average of 3 pounds grain $CP_1$, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 59, 1917.* October 26 to December 26, 3 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 63, 1917–18.* December 1, 1917, to February 1, 1918, 3 pounds grain C, 8 pounds corn stover, 30 pounds corn silage.

*Cow 63, 1919.* February 3 to March 10, alternated rations with daily average of 3 pounds grain $CP_1$, 4 pounds alfalfa hay, 24 to 30 pounds corn silage. March 11 to 28, 3 pounds grain C, 4 pounds alfalfa hay, 24 pounds corn silage; rations not alternated. March 29 to April 25, same as February 3 to March 10.

*Cow 64, 1918–19.* December 9, 1918, to January 5, 1919, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage. January 6 to February 6, 1919, 6 pounds grain C, 5 pounds alfalfa hay, 30 pounds corn silage.

*Cow 67, 1918.* April 1 to 20, alternated rations with daily average of 3 pounds grain $CP_2$, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 70, 1918–19.* October 19, 1918, to January 27, 1919, alternated rations with daily average of 3 pounds grain $CP_1$, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 71, 1918.* September 25 to December 1, 3 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage. December 2 to 11, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 71, 1919–20.* December 20, 1919, to February 20, 1920, alternated rations with daily average of 3¼ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage. February 20 to March 1, 1920, alternated rations with daily average of 5¼ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage.

*Cow 81, 1919.* February 24 to April 24, 1919, 3 pounds grain E, 3 pounds alfalfa hay, 30 pounds corn silage, 5.7 grams Ca as $CaCl_2$ daily.

*Cow 81, 1920.* February 13 to April 6, alternated rations with daily average of 3¼ pounds grain CP, 3 pounds alfalfa hay, 30 pounds corn silage.

*Cow 213, 1918.* January 1 to February 6, 5.6 pounds grain C, 3 pounds soybean hay, 8 pounds corn stover, 25 pounds corn silage.

*Cow 214, 1918.* March 28 to May 6, alternated rations with daily average of 3 pounds grain $CP_2$, 4 pounds alfalfa hay, 30 pounds corn silage. May 7 to 15, alternated rations with daily average of 5 pounds grain $CP_2$, 4 pounds alfalfa hay, 30 pounds corn silage. May 16 to 27, alternated rations with daily average of 5 pounds grain $CP_1$, 4 pounds alfalfa hay, 30 pounds corn silage.

### Animals which had been on test during the year preceding the experiments

For a month or so before they calved previous to the test lactation period these animals were fed daily rations of from 8 to 18 pounds grain F, 10 to 16 pounds alfalfa hay, and 24 to 30 pounds corn silage. The grain mixtures fed contained more protein and ash than either grain C or grain D. The rations supplied a great excess of both protein and total nutriment above the maintenance requirements.

After they had finished their tests, these animals were dried off about two months before they were due to calve. Cows 227, 232 and 240 were selected as controls and were fed 3 pounds grain D, 5 pounds alfalfa hay and 30 pounds corn silage for 60 days before calving. Cows 228, 229, and 248 served as experiments. For 60 days before calving they were fed alternated rations with a daily average of 3½ pounds grain DP, 5 pounds alfalfa hay, and 30 pounds corn silage.

### *Comment on comparisons of table 2*

*Cow 17.* This animal gave very little more milk after the phosphate feeding than after the control feeding. She had a long dry period in both cases. It seems likely that the long dry period enabled her to

restore any insufficiency of bone material which may have existed at the beginning of the experiment. She had a uterine infection after the experimental feeding, which may have reduced her milk somewhat in the experimental period.

*Cow 49.* This animal aborted during the period of phosphate feeding 39 days before term. The abortion greatly shortened her dry period on the phosphate feeding and prevented her receiving the more liberal

TABLE 2

*Condensed history of animals used in the experiments. Animals from the general herd used both as experiments and controls*

| NUMBER OF ANIMAL | DATE OF BIRTH | BREED | DATE OF CALVING | | DAYS DRY | | MILK YIELD* | | FAT YIELD* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | After control feeding | After phosphate feeding | Control period | Phosphate period | After control feeding | After phosphate feeding | After control feeding | After phosphate feeding |
| | | | | | | | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 17 | 1909 | Grade Jersey | 12–11–18 | 3–29–20 | 122 | 122 | 847 | 858 | 33.9 | 33.5 |
| 49 | 10–22–14 | Grade Guernsey | 12–25–18 | 1–14–20 | 71 | 36 | 831 | 953 | 40.7 | 43.8 |
| 50 | 10–25–14 | Grade Holstein | 6–3–20 | 12–20–18 | 73 | 98 | 995 | 972 | 38.8 | 38.9 |
| 54 | 1–22–15 | Grade Guernsey | 5–14–17 | 6–2–19 | First calf | 61 | 669 | 1027 | 24.1 | 34.9 |
| 63 | 10–17–15 | Grade Holstein | 2–1–18 | 4–25–19 | First calf | 103 | 422 | 1018 | 15.5 | 34.1 |
| 71 | 7–15–16 | Grade Guernsey | 12–11–18 | 3–1–20 | First calf | 60 | 632 | 1121 | 29.1 | 49.3 |
| 81 | 2–19–17 | Grade Guernsey | 4–24–19 | 4–6–20 | First calf | 44 | 685 | 936 | 26.0 | 42.1 |

* The figures given in these columns represent the number of pounds of milk and fat given from the 10th to the 40th day after calving, except in the case of Cow 54. In this case it was necessary to take the figures for the yields from the 18th to the 48th day after calving, as the daily milk records from the 10th to the 17th day in 1917 had been lost.

grain ration which she had eaten for 23 days before calving during the control period. In the general herd, abortions 5 weeks or more before term have decreased the milk yield from 30 to 50 per cent. We have no way of accounting for the increased milk which was given in this case after the abortion, except as the result of the phosphate feeding.

*Cow 50.* This animal was fed a much more liberal grain ration than the others in both the control and experimental periods. She "leaked"

milk from her udder to a considerable extent through the experimental period, and she had a uterine infection after calving in the control period, which may have somewhat reduced her milk yield. She gave a little more milk in the control period than in the experimental period. The numerous disturbing circumstances make it difficult to interpret the results, but they seem to us to indicate that the addition of phosphate will often have little effect when the basal grain ration is as high as 5 pounds daily.

*Cow 54.* This cow aborted during the phosphate feeding 28 days before term. Judging from the history of such cases in the general herd, her milk yield should have been about 10 per cent less than after the control feeding. We have no way of accounting for the actual increase except as the result of the phosphate feeding.

*Cows 63, 71, and 81.* The remaining three animals of table 2 were fed on the control rations before their first calves were born and on the experimental rations before their second calves were born. It is well known that heifers are likely to give more milk with their second than with their first calves, the average increase has been worked out by Pearl and Patterson (7) for Jerseys, and we have in the Department figures obtained from the cow-testing associations for Guernseys and Holsteins. In table 9 we have given the actual and expected increases; in calculating the expected increases, we have in each case used the set of figures which would give the largest increases, in order to avoid any possible suspicion of favoring the results of the phosphate feeding. The milk yield of all three heifers increased after the phosphate feeding decidedly more than would be expected as the result of age alone. We have no way of accounting for the additional increases, except as the result of the phosphate feeding.

### *Comment on comparisons of table 8*

The animals of which the histories are here tabulated were used in early experiments, in which we were still feeling around for the conditions under which the effects of the phosphate feeding would stand out most sharply, and in which the treatment of the subjects was not so carefully controlled as in the later experiments. The results, however, are in general accord with those of the later experiments, and it has seemed to us worth while to report them.

It would, perhaps, be fair to compare cow 59 with cows 67 and 70; cow 64 with cow 21; and cow 213 with cow 214. The figures for cow

59 represent approximately the average performance for the heifers of the general herd with their first calves. Cow 67 is a half sister of cow 59. The two animals have the same sire; the dam of 67 has a somewhat better record than that of 59. Cow 70 was selected in order to try the effects of phosphate feeding in an unfavorable case. Her mother had the poorest record of any cow in the herd except two, and she herself was of unpromising appearance. Cow 64 was milked only

TABLE 3

*Condensed history of animals used in the experiments. Animals from the general herd used only either as experiment or control*

| NUMBER OF ANIMAL | DATE OF BIRTH | BREED | DATE OF CALVING | DAYS DRY | MILK YIELD* | FAT YIELD* |
|---|---|---|---|---|---|---|
| | | | Controls | | | |
| | | | | | *lbs.* | *lbs.* |
| 59 | 8–10–15 | Grade Hol-Holstein | 12–26–17 | First calf | 568 | 20.5 |
| 64 | 10–18–15 | Grade Holstein | 2–6–19 | 62 | 1108 | 40.1 |
| 213 | 9–26–15 | Holstein | 2–6–18 | First calf | 742 | 26.7 |
| | | | Experiments | | | |
| 21 | 1907 | Grade Jersey | 11–30–18 | 85 | 1458 | 60.9 |
| 67 | 12–29–15 | Grade Holstein | 4–20–18 | First calf | 753 | 26.3 |
| 70 | 4–22–16 | Grade Guernsey | 1–27–19 | First calf | 588 | 28.3 |
| 214 | 3–18–16 | Holstein | 5–27–18 | First calf | 1554 | 46.8 |

* The figures given in these columns represent the number of pounds of milk or fat given from the 10th to the 40th day after calving.

twice a day; and cow 21, three times. The difference in the milk yields is, however, larger than is generally produced by this difference in treatment. Cows 213 and 214 were half sisters, both being daughters of the same sire. The dam of cow 213 had a decidedly better record than that of cow 214. Cow 213 was milked only twice a day; and cow 214 three times, but the difference in milk yields is very much greater than could be accounted for by this difference in treatment.

*Comment on comparisons of table 4*

We do not think it necessary to make any detailed comment on the results given in table 4.

The differences in milk yield as between the cows fed phosphate and those fed the basal ration alone are so small as to be insignificant.

TABLE 4

*Condensed history of animals used in the experiments. Animals which had been on test during the year preceding the periods of control and phosphate feeding*

| NUMBER OF ANIMAL | DATE OF BIRTH | BREED | DATE OF CALVING | | DAYS DRY | | MILK YIELD* | | FAT YIELD* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Test period | After control or phosphate feeding | Before test period | Control or phosphate feeding period | Test period | After control or phosphate period | Test period | After control or phosphate feeding period |
| **Controls** | | | | | | | | | | |
| | | | | | | | lbs. | lbs. | lbs. | lbs. |
| 227 | 8–2–15 | Holstein | 4–18–18 | 1–11–20 | First calf | 137 | 1674 | 2019 | 61.8 | 83.8 |
| 232 | 3–31–16 | Holstein | 11–29–18 | 3–15–20 | First calf | 58 | 1591 | 2046 | 45.5 | 67.5 |
| 240 | 11–10–14 | Holstein | 9–27–18 | 2–9–20 | 59 | 112 | 1876 | 1881 | 64.2 | 80.9 |
| **Experiments** | | | | | | | | | | |
| 228 | 9–2–15 | Holstein | 4–4–18 | 12–30–19 | First calf | 79 | 1429 | 2016 | 44.7 | 64.9 |
| 229 | 11–8–15 | Holstein | 5–28–18 | 1–31–20 | First calf | 94 | 1817 | 2078 | 53.8 | 71.7 |
| 248 | 3–15–16 | Holstein | 1–22–19 | 6–17–20 | First calf | 63 | 1594 | 1611 | 51.0 | 45.1 |

* The figures in these columns represent the milk and fat yields from the 10th to the 40th day after calving except in the case of Cow 229. In her case they represent the milk and fat yields from the 20th to the 35th day after calving multiplied by 2. It was necessary to take these figures instead of the usual ones, as she was sick for some days after calving in 1920, and suffered a severe cut in her rations, and got sick again on the 36th day after calving.

It follows that the favorable influence of the phosphate feeding is reduced to negligible proportions in the case of cows which have been super-abundantly fed in their immediately preceding lactation period.

*Effects of phosphate feeding on body weight*

Both the animals on the experimental feeding and those used as controls were weighed from time to time. The results are given in tables 5, 6, 7 and 8. These figures summarize all the pertinent results that we

TABLE 5

*Body-weights of animals on control and phosphate rations. Heifers on control rations; all four pregnant*

| NUMBER OF ANIMAL | PERIOD DURING WHICH WEIGHINGS WERE TAKEN | AVERAGE DAILY GAIN | DAILY RATION | | |
|---|---|---|---|---|---|
| | *days* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 67 | 20 | 1.75 | Grain C..... 3 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 71 | 60 | 0.65 | Grain C..... 3 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 81 | 180 | 1.04 | Grain E..... 3 | Alfalfa hay.. 3 | Corn silage.. 30 |
| 214 | 59 | 0.90 | Grain C..... 3 | Alfalfa hay.. 4 | Corn silage.. 25 |

TABLE 6

*Body-weights of animals on control and phosphate rations. Heifers fed alternated rations with phosphate; no. 70 pregnant, no. 74 farrow*

| NUMBER OF ANIMAL | PERIOD DURING WHICH WEIGHINGS WERE TAKEN | AVERAGE DAILY GAIN | AVERAGE DAILY RATION | | |
|---|---|---|---|---|---|
| | *days* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 70 | 70 | 1.24 | Grain $CP_1$ .. 3 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 74 | 80 | 2.20 | Grain $CP_1$ .. 3 | Alfalfa hay.. 4 | Corn silage.. 30 |

TABLE 7

*Body-weights of animals on control and phosphate rations. Cows fed control rations during dry periods before calving*

| NUMBER OF ANIMAL | PERIOD DURING WHICH WEIGHINGS WERE TAKEN | AVERAGE DAILY GAIN | DAILY RATION | | |
|---|---|---|---|---|---|
| | *days* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 17 | 50 | 1.38 | Grain C..... 4 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 50 | 59 | 1.76 | Grain C..... 5 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 51 | 47 | 1.28 | Grain C..... 3 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 64 | 60 | 1.32 | Grain C..... 6 | Alfalfa hay.. 5 | Corn silage.. 30 |

have. Heifers 67 and 214 were fed on the control rations in the late winter of 1917–1918 and changed over to the experimental rations a few weeks before they calved. They, therefore, figure as controls in table 5 and as experiments in table 3. They were on the experimental

feeding for such short periods that the weights obtained from them during those periods can not be used in the present discussion.

It seems worth while to give in more detail the histories of two animals of which the weight changes on the experimental feeding were followed for comparatively long periods.

TABLE 8

*Body-weights of animals on control and phosphate rations. Cows fed alternated rations with phosphate during dry periods before calving*

| NUMBER OF ANIMAL | PERIOD DURING WHICH WEIGHINGS WERE TAKEN | AVERAGE DAILY GAIN | AVERAGE DAILY RATION | | |
|---|---|---|---|---|---|
| | *days* | *lbs.* | *lbs.* | *lbs.* | *lbs.* |
| 17 | 52 | 0.93 | Grain CP... 4½ | Alfalfa hay.. 4 | Corn silage.. 30 |
| 21 | 80 | 1.57 | Grain $CP_1$.. 6 | Alfalfa hay.. 5 | Corn silage.. 30 |
| 50 | 30 | 2.50 | Grain $CP_1$.. 5 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 71 | 30 | 1.87 | Grain CP... 3 | Alfalfa hay.. 4 | Corn silage.. 30 |
| 81 | 31 | 1.03 | Grain CP... 3 | Alfalfa hay.. 3 | Corn silage.. 30 |

Heifer 74 was born October 15, 1916. From October 19, 1918 to January 15, 1919, she was fed alternated rations with phosphate, receiving as a daily average 3 pounds grain $CP_1$, 4 pounds alfalfa hay and 30 pounds corn silage. She was still farrow during this period. Her weights were as follows:

| | *pounds* |
|---|---|
| October 24 | 754 |
| November 23 | 804 |
| December 23 | 890 |
| January 12 | 930 |

Cow 21 was born in 1907. From August 28 to November 30, 1918, she was fed alternated rations with phosphate, receiving as a daily average 6 pounds grain $CP_1$, 5 pounds alfalfa hay, 30 pounds corn silage. She had calved previously, November 7, 1917, and became dry September 6, 1918. She calved again November 30, 1918. During the period of phosphate feeding, her weights were as follows:

| | *pounds* |
|---|---|
| September 2 | 1027 |
| October 2 | 1107 |
| November 1 | 1143 |
| November 21 | 1153 |

Her best previous month's record for milk yield on the Beltsville farm was made in October, 1914, and amounted to 1041 pounds. After this, her milk yield gradually fell off; the best month's production after the 1917 calving was 469 pounds. She was in very good condition when she calved in 1918: in December, 1918, she produced 1276 pounds of milk; and in January, 1919, 1315 pounds.

These two cases show clearly that sodium phosphate may be fed to cows for long periods in large amounts without producing any deleterious effects on the digestive and assimilative processes.

TABLE 9

*Basis for an attempt to estimate how much the alternated feeding with phosphate increased the milk yield in the cows of the general herd under the conditions of our experiments. The column headed "Expected yield after alternated rations with phosphate" gives the milk yields to be expected after the experimental feeding, using the yields after the control feeding as a basis, and taking into account the facts that the animals were generally older during the experimental feeding and that some of them aborted. The figures represent pounds of milk yielded in 30 days beginning soon after calving*

| NUMBER OF ANIMAL | ACTUAL MILK YIELD AFTER CONTROL RATIONS | EXPECTED MILK YIELD AFTER ALTERNATED RATIONS WITH PHOSPHATE | ACTUAL MILK YIELD AFTER ALTERNATED RATIONS WITH PHOSPHATE |
|---|---|---|---|
| | *lbs.* | *lbs.* | *lbs.* |
| 17 | 847 | 847 | 858 |
| 49 | 831 | 565 | 953 |
| 50 | 995 | 995 | 972 |
| 54 | 660 | 599 | 1027 |
| 63 | 422 | 495 | 1018 |
| 71 | 632 | 739 | 1121 |
| 81 | 685 | 753 | 936 |
| Totals..... | 5081 | 4993 | 6885 |

The actual yields after the alternated feeding with phosphate average 37.9 per cent more than the expected.

### *Account of unsuccessful and incomplete experiments*

Many experiments on the effects of phosphate feeding were begun and then had to be abandoned because the animals aborted or failed to calve, or for other reasons. In other cases phosphate was fed to certain animals, but under rather different circumstances from those in the experiments which have been reported. We wish to speak briefly of these unsuccessful and incomplete experiments partly because the re-

sults sometimes furnished interesting hints, partly in order to avoid any suspicion that the results reported for the successful experiments might be cases unconsciously selected in which the milk yield happened to be large after the phosphate feeding.

Several animals were started on the control rations, and then either aborted or turned out to be sterile. It is not necessary to say anything about these, further than that, in the cases where they aborted, the milk yields were such as would be expected from a consideration of their histories in comparison with those of the rest of the general herd.

Cow 63, the histories of whose 1918 and 1919 lactation periods have already been given in detail, was started again on the basal rations in 1920. She carried her calf to term, but acquired an acute general infection after she had been milking about two weeks, which rapidly reduced her milk yield to a very low point, and finally made it necessary to have her slaughtered. She began this lactation period, however, with a milk yield which promised to be as good as or better than that of 1919 after the phosphate period. It is to be remembered that her dry period in 1919 on the phosphate feeding was 103 days; and her dry period in 1920 was also about 100 days. We are inclined to think that these long dry periods made it possible for her to store up a good quantity of calcium and phosphorus, and it would not be surprising if the effect of the long dry period with phosphate feeding in 1919 lasted over into 1920.

Several cows started on the phosphate feeding turned out to be sterile; and one aborted, in addition to Cows 49 and 54, whose histories have already been reported in detail. The abortion in question occurred at a period when it was the custom to remove aborting cows from the farm immediately, and before we realized that cows which aborted after a period on the phosphate feeding might give more milk than they ever had before. We have no knowledge of the amount of her milk yield after the abortion.

Besides the cases so far reported, there are only seven animals which have received any sodium phosphate at all. One of these received small daily doses (6.9 grams P as sodium phosphate) from the time she was born up to when she threw her first calf. She aborted with this calf, and gave a rather small quantity of milk subsequently. On account of the abortion and of the fact that the doses of phosphate were small, we do not think that this experiment throws any light at all on the question of the effects of phosphate feeding on the subsequent milk yield.

The other six animals received basal rations alone, and then the same rations with phosphate added, for short alternated periods, the

main purpose of the experiments being to determine the effects of feeding phosphate on the concentration of phosphorus in the blood. Three of these happened to abort after periods of a week or more on rations without phosphate. They gave about the quantities of milk which would have been expected on the supposition that they had never had phosphate.

The other three threw their calves while on the phosphate feeding. Two of them aborted after seven and ten days of phosphate feeding respectively. Both gave more milk than they ever had before, and decidedly more than would have been expected on the supposition that they had never had phosphate. The third was a heifer carrying her first calf. She calved normally at term after 26 days of phosphate feeding and gave much more milk than the general average for the herd with their first calves. These last three results suggest that even a short period of phosphate feeding may have a markedly favorable effect on milk yield if it occurs during the few days immediately before calving, during which the udder is rapidly enlarging in preparation for the coming lactation period.

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# OFFICIAL GRADING AND CONTROL OF DAIRY PRODUCE FOR EXPORT

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In bringing this subject before the convention I wish to state at the outset that while I personally believe in the principle of grading dairy produce and other commodities for export, I am not here at the moment to advocate the adoption of such a system in connection with the export of our butter and cheese, or to urge it upon the dairymen of Ontario at the present.

Some months ago, at a conference with the provincial deputy ministers of agriculture, the subject was discussed, and it was agreed that the grading of dairy produce for domestic trade or for educational purposes might be considered a provincial function, but that grading for export was essentially a dominion function. During the last session of Parliament a resolution calling upon the government to establish a grading system for export dairy produce was introduced in the House of Commons. It received unanimous support from the members. The minister of agriculture in his reply accepted the principle of the resolution, and stated that when the producers were ready to have their butter and cheese graded the Dairy Branch would be prepared to carry out such a scheme. While the attitude of the House on this question might almost be taken as a mandate, the reply of the minister gives you the policy of the department in the matter. In other words, when you intimate that you are desirous of having such a service performed, means will be found to carry it out, but it is not the intention of the minister to force it upon the country. In the meantime we feel that while this matter is being discussed and receiving some attention from all progresive dairymen, that it is our duty to collect and disseminate as much information on the subject as possible.

The grading of produce is not a new idea, and it is over twenty years since it was first applied to butter and cheese. As a mat-

ter of fact the principle of grading has always been recognized in the Canadian cheese and butter trade. In selling your cheese the price is usually fixed on the basis of no. 1 quality. On delivery the buyer inspects the shipment and decides whether the quality is up to the standard of no. 1 quality or should be rated lower. Thus you have a rather crude attempt at grading, but its great weakness is that the grader is an interested party, to whom it is an advantage to have the grade reduced as low as possible. Such a one-sided system breeds suspicion and leads to discontent. The wonder is that there has not been greater dissatisfaction than there is. It speaks well for the character of the buyers of cheese that such a loose method should have prevailed for so many years.

Then the question before us is not so much the introduction of grading as something new, as it is the substitution of an organized system carried out by disinterested parties with a legal status and based on clear-cut definitions, for the present one-sided and haphazard arrangement. In other words whether the quality of every lot of cheese shall be determined accurately and the price fixed according to value, or that the matter shall be left entirely in the hands of one party to the transaction, who may be influenced by market conditions and other considerations.

Official or government grading of dairy produce has been in force in different countries for a good many years, and we now have in Canada a number of grading services in operation. It may be worth while at this stage to state very briefly how these different services are carried on and the particular object that was in view when they were organized.

Let us begin with New Zealand, because that country was the first to adopt government grading of dairy produce—about twenty-five years ago—and because it is the only country in the world from which no dairy produce may be exported unless it is graded. The grading of butter was started in New Zealand as an educational measure, and to give information to the butter-makers as to the quality and character of the butter which they were turning out. When this matter was first taken up there were no regular exporters in that country. The export butter

and cheese were mostly handled by wholesale importing firms who bought New Zealand produce or secured the shipping of it in order to help out their exchange. There was no examination or inspection of the butter or cheese at the time of shipment. It was usually consigned to some importer in London. It was from three to six months old before it reached its destination and then another month or two would elapse before definite reports on the quality came back to the maker. It was this state of affairs that induced the government to inaugurate a system of examination, largely for the purpose of giving information and guidance to the makers.

The application of a complete grading system in New Zealand was comparatively simple compared to what it would be in Canada, and I need only describe briefly the geographical situation and other conditions to make this quite clear. In the first place New Zealand is a small, compact and insular country. Export is possible by steamer only. All the towns and shipping centers are at the seaboard, and the cold storage warehouses where the butter and cheese are stored are located on the docks so that vessels are loaded direct from the warehouses. Home consumption is relatively small and the bulk of cheese and butter produced is exported. The result is that the great majority of factories make butter and cheese for export only, and when it is shipped from the factory to the cold storage warehouse there is never any doubt as to whether it is to be exported or held for local trade. The local trade is taken care of by certain factories which do not go into the export trade as a rule. The grading of dairy produce in New Zealand is carried out under the dairy produce act and regulations thereunder. The butter or cheese, as the case may be, must be shipped regularly to certain specified cold storage warehouses. All export butter and cheese must go through these warehouses. The regulations require that the churning number shall be marked on each box of butter and the vat number on each box of cheese, so that the grader may select one package from each churning or vat in the shipment and score the whole as one lot. The grading is done as the butter or cheese is being transferred from the railway cars or trucks to the govern-

ment cold store. When the grade has been determined one or other of the grade marks, "1," "2," or "3," as the case may be, are placed on each package in the shipment. After grading and marking, the butter and cheese are wholly under the control of the government officer in charge of the grading station, and the owner has no access to them. He gives his instructions as to when and to whom they should be shipped and the manager of the warehouse attends to the shipping details. There is no such thing in New Zealand as a "through" bill of lading issued at interior points. Then again, none of the exporters have warehouses of their own. They couldn't use them if they had, for everything must go to the government grading store. In New Zealand the export trade was developed under the grading system, and therefore fits into it, while our export trade has been free to develop without restrictions of any kind, and has got into channels which are now well worn and certain customs are rather firmly established. Another essential difference in the export trade of the two countries is that in New Zealand the disposal of the year's output is usually arranged for at the opening of the season, and prompt and regular shipment is the rule. Indeed the regulations, while they require that butter must be in store for three days after grading, also require that it shall be shipped out by the first available steamer thereafter. I need not point out how this practice differs from our own.

Designed at first as a purely educational scheme, as time went on the commercial value of the New Zealand grader's certificate became more and more recognized, until today it is of first importance. Sales are now based almost wholly on the grades, of which the grader's certificate is visible and accepted evidence.

In Australia a similar system is in force under state authority, and varies somewhat in the several states which have made any attempt at grading.

I have pointed out the difference between New Zealand and Canada in regard to the export trade in dairy produce that the difficulties of setting up such a system in this country may be appreciated, and to show that some "give and take" will be necessary before it is, if ever, an accomplished fact.

In South Africa they have a law which provides for the grading of all kinds of produce, which may be applied in different localities by Order-in-Council. All the cheeses are now graded which are shipped from one dairying district. The manufacture of cheese and butter has not yet reached large proportions in South Africa, the net export of cheese in 1918 being only 191,085 pounds.

In the United States, under the Food Products Inspection Law, the federal dairy division has appointed inspectors, who are located at Boston, New York, Philadelphia, Chicago, and Minneapolis. These inspectors are prepared to grade butter on application of anyone having a financial interest in the shipment, but they do not undertake any inspection or grading of their own volition. This comes under the head, therefore, of voluntary or optional grading. It is confined to the five cities which I have mentioned. There are some interesting points in connection with the United States inspection service, and if anyone wishes to obtain more particulars I would suggest that he write to the Bureau of Markets, Department of Agriculture, Washington, and ask for Service and Regulatory Announcement No. 51.

In Canada we already have some grading carried on under both federal and provincial and other authorities. It is both official and unofficial. In some cases it is carried out for educational purposes, while in others the object is purely commercial, but all the grading being done in Canada at the present time is more or less voluntary and has no authority of law behind it.

I think it is only fair to say that the first grading of butter in Canada was carried out in Alberta. The sample system is followed, and it is not compulsory, although practically all the creameries in the province avail themselves of the service. No Alberta creamery can sell its butter to advantage in the British Columbia market unless it is covered by the Alberta grader's certificate, as some of the creameries have learned to their cost when they have attempted to act independently of the grading system.

The grading of butter is also carried out in both Saskatchewan and Manitoba along the same lines as those followed in Alberta,

and it may be said now that the great bulk of all the creamery butter produced in the prairie provinces is graded by the different provincial authorities. There is no doubt that the grading of butter has been an important factor in winning for the butter of the prairie provinces the strong position which it holds today.

The Dairy Branch of the Provincial Department of Agriculture at Toronto has, as most of you know, been conducting a voluntary or optional butter grading service on the sample plan for the last three years.

The Quebec Agricultural Coöperative Society has been grading cheese and butter in bulk for sale by auction in Montreal for some years past. The Society practically does its own grading although it has the backing of the Provincial Department of Agriculture.

The Montreal Produce Merchants' Association employs an inspector who passes judgment on the quality of butter and cheese in transactions in which the members of the Association are interested. This is the only instance of purely unofficial grading being carried on in Canada at the present time.

The Dairy Branch at Ottawa has undertaken to grade the cheeses which are to be sold by auction by the United Dairymen Coöperative at Montreal. A certificate is issued in duplicate, one copy going to the purchaser and one copy to the Manager of the Coöperative Society, who passes it on to the factory. The grading at Montreal is on a purely commercial basis, although it is possible to use the information for educational purposes by passing it on to the instructors.

In the province of New Brunswick during the past two years practically all the cheese manufactured has been graded for the local market by an official of the Provincial Department of Agriculture. The dealers agreed to purchase only graded cheese and to scale the price as between first, second and third grades. The quality of New Brunswick cheese has shown marked improvement under this stimulus and relatively a much better price has been obtained for it.

During the years 1917 and 1918, when the cheese was handled by the Cheese Commission and the Dairy Produce Commission,

every box exported was to all intents and purposes classified into no. 1, no. 2, or "off grades," according to the now generally adopted Canadian standards and definitions. The cheeses were classified by the dealers who offered them to the Commission, but the Commission inspected every lot to see that the classification was according to quality, and a definite spread of one-half cent per pound was made in the price as between first and second grades.

Thus you see, from the foregoing statements, that a considerable amount of grading is being done in Canada at the present time, according to different plans and under different auspices and having different objects in view. It would be, however, a very long step from the present voluntary or optional grading service which is carried out here and there, to a complete or general and compulsory service for the grading of all dairy produce to be exported. There are, however, no insuperable difficulties in the way. It is quite possible that it might be found desirable to apply it with certain limitations. For instance, it would be a comparatively simple requirement to say that only the cheese and butter exported through the port of Montreal to the United Kingdom should be graded. That would be very different to requiring that all dairy produce for export should pass through that port to be graded. Occasional shipments of butter or cheese to the United States, to the West Indies, or other places, not passing through Montreal at all, might be exempted from the provisions of any regulations governing the grading of dairy produce. These are matters that would all have to be considered before any definite decision could be reached. The main thing for us to consider at the present time is what are the advantages or disadvantages that might be expected to arise from the adoption of a grading system.

Having been responsible for the reorganization of the grading service in New Zealand while I was dairy commissioner in that country, I have naturally watched the working out of the policy with very much interest. It is as clear to me as it can be that the grading system has been of immense value to the New Zealand dairying industry. As an educational measure it has been a

strong factor in raising the standard of quality. The confidence established in the British market and the simplification of trading has tended to popularize New Zealand produce in the old country, and don't forget that popularity does not rest solely on the matter of quality. Although quality is of first importance, standardization, confidence and elimination of disputes over quality, all of which grading promotes, go a long way in building up a reputation for any article.

It is worthy of note that in 1917 the percentage of no. 2 cheese received by the Cheese Commission was 15.13 per cent of the whole. In 1918 the percentage of no. 2 cheese was only 11.16 per cent, and it is a fair assumption that a considerable amount of credit for this improvement should be given to the grading of the cheese.

Some very interesting results have followed the grading of the cheeses which were sold by auction at Montreal during the past season by the United Dairymen Coöperative. Let me give you one instance. The cheeses from a certain factory were all graded no. 2 for the first four sales; after that they were never lower than no. 1, three lots were graded "special," and one lot made the record high score for colored cheese. Can anyone doubt the value of grading to that factory? Under the present system it is not always brought home to the factory as it should be when there is any falling off in the standard of quality. Very often, owing to market conditions and for other reasons, no fault is found with the quality, although it may be only a second grade. While there may be a temporary gain to the factory which sells a no. 2 article for a no. 1 price the result is very bad in the end as it engenders a false sense of security and tends to perpetuate the errors. It is in the interest of the factory in the long run that it should be advised, regardless of market or any other condition, as to the exact quality of its product.

As for the disadvantages attending the adoption of a grading system, I do not see that there are any. It will fit in with the present methods of selling cheese either coöperatively by auction, or on the cheese boards. No expense will be added to the handling of either cheese or butter, nor will the business of anyone connected with the trade be necessarily disturbed.

It will be necessary to have some legislation and regulations to govern the carrying out of such an important line of work. As far as the factories are concerned no obligations will be imposed, nor will they be required to do anything which they are not doing now, except possibly to mark the number of the vat or the number of the churning on each package. I cannot understand why they do not do that now, without any compulsion. I could point out case after case where factories have lost much money through their failure to observe this very simple requirement.

We come now to the second part of my subject, namely, that of government control of exports.

I have seen it stated that the butter exported from Denmark is graded, but this is not the fact. There is, however, a very important system of control over the export of butter not only in Denmark but in Sweden and Holland, and it may be interesting to describe these systems at this point, because the results commercially are similar, in some respects, to those which follow a system of grading.

No butter of Danish origin may be exported from that country which does not bear the national or "Lur" brand. This brand may not be used on any butter shipped out of the country but manufactured elsewhere, and no creamery is permitted to use it unless the butter comes up to a certain standard of quality. Nominally the government administers these regulations, but in reality it is the creameries themselves that have taken the initiative in this as in other matters, and in effect the Union of Danish Creamery Associations say to the dishonest, careless, or inefficient creamery, "We will not allow you to export your inferior butter and thus injure the general reputation of Danish butter and prevent those of us who produce a first-class article from getting the maximum price for it."

The national or "Rune" brand of Sweden is applied in much the same way as the Danish national brand, and for the same reasons.

In Holland a slightly different system of control prevails. Holland is a great dairying country, in some respects the greatest in the world. For intensive production, for thoroughness of

organization, and for superiority of buildings and equipment it excels any other country that I know. But Dutch butter at one time acquired a rather bad reputation for adulteration, and it lost popularity in the British market on that account. Dutch butter sold from 3 to 4 cents per pound below that of Danish, although the quality of much of it was undoubtedly just as good. That was the result of lack of confidence. The Dutch government, therefore, took the matter in hand and established a system of control under which frequent examinations are made of the butter of any creamery that desires to come under the system, and when the authorities are satisfied that the creamery in question is turning out a pure article of good quality they are allowed to use the government control mark, which consists of a very thin piece of paper printed with certain wording and so cut or scored that when it is once pressed on the surface of the butter it seems to be impossible to remove it without tearing it all to pieces. These paper marks are supplied by the government, and each bears a number for the purpose of identification.

These systems of control serve to some extent the same purpose as that of grading, except that there is no certificate issued which can be used as a commercial document. They are more applicable, it seems to me, to countries in which the bulk of the produce has reached a high level of quality and is generally uniform throughout. The control system is not of the same educational value to the butter-maker or to the creamery or cheese factory as a system of grading is.

Returning to the matter of grading, I need hardly point out that it may take a good many different forms and be applied in various ways and with different objects in view. Thus it may be educational in its object, or it may be purely commercial, or a combination of both; it may be compulsory or merely optional or voluntary; it may be confined to either the export or home trade, or it may cover both wholly or in part; it may be official through a government department, or unofficial as where the grader receives his authority from a voluntary organization. In a country like Canada it may be carried out under either federal or provincial auspices; and finally, the grading may be done on

samples or in bulk. So when we talk about a grading system, it is well to know just what we have in mind.

My final point is that as our principal competitors in the British market have adopted some measure of grading or other control over exports, it would seem to be the part of wisdom for us to give the matter careful consideration, with due regard to the difference in our conditions as compared with these other countries. With grading in New Zealand, Australia, and South Africa, with regulation of exports by which dairy produce of inferior quality is not allowed to leave Denmark and Sweden, and with Holland guaranteeing the quality of butter and cheese bearing the government mark, we are not going to have things all our own way.

Personally, I have not in the past been a very enthusiastic advocate for the adoption of a general system of grading, because I did not believe that this country was ready for it, but I will go farther than I did in opening and say that I believe now that the time has come when if we are to hold our own under the keen competition, keener than it has ever been before, we must take advantage of every means of placing our surplus of dairy produce on the world's markets under the most favorable conditions possible. A system of grading for export dairy produce, if adopted, would have in this country a threefold object. First, it would be educational; second, it would facilitate trading and promote confidence in our produce; third, it would give the maker of the high grade article full recognition and reward.

It would be educational because the grader's reports or certificates on low grade produce would show the maker wherein his produce was defective. Without such information he must rely on the opinions and reports of the buyers, and with all due respect to these gentlemen, I do not hesitate to say that very frequently opinions expressed by them are misleading, because in some cases they have not the necessary practical knowledge, and it is not always in the interest of the buyer to find fault with the quality of his purchase. I repeat that, generally speaking, there are few complaints as to quality and no reduction in price when the market rises, and thus the maker is misled and repeats his errors.

When complaints are made on a falling market the maker does not believe in the fairness of the claim and attributes it wholly to a question of market conditions. A grading system would eliminate these misunderstandings and disputes over quality. The maker of high grade butter or cheese does not, under the present system, receive his just reward. There is a tendency to fix the price on the average quality, as the buyer does not care to incur the onus of criticizing or rejecting. He would rather pay one price and then clear himself by taking losses on part of it if necessary and making a larger profit on the goods of higher quality. No fault can be found with anyone on this score because it is the natural outcome of our present method of doing business.

In conclusion let me say this, that no one has a higher appreciation of the outstanding position which Canadian cheese has reached in the world's market than I have. It is the largest item in the international trade, and in the matter of quality it stands absolutely at the top. We have reached this position without any system of grading but it must be remembered that while we were making our reputation no other country had such a system. Our position as the largest exporter of cheese in the world is being threatened to some extent by New Zealand, but I am of the opinion that it will be many years before New Zealand exports as much cheese as Canada does. At the present moment there is a tendency to swing back to butter-making in New Zealand. Our production of cheese has been reduced to some extent in recent years by the great extension of the condensed milk and milk powder industry. The recent check to the condensed milk industry would indicate that the cheese industry has nothing to fear from that source in the near future. We cannot, however, continue to hold our position in the cheese trade unless we are prepared to meet our competitors on equal footing, and the development of the grading idea all over the world is something which we cannot afford to ignore.

With regard to butter, our position is very much weaker. The surplus for export is comparatively small. It will probably be in the neighborhood of 16,000,000 pounds for the season of

1920. The quantity is irregular, and our reputation suffers from the fact that a great deal of the butter is held during the summer months for speculative purposes. There is every indication, however, that our exports of butter will show very considerable increase in future years, and if it is to win as favorable a position as our cheese has we must do everything in our power to meet a competition which is even keener in the case of butter than it is in that of cheese.

I have endeavored to put the facts of the situation before you as clearly as possible in order that you may understand it and act accordingly.

# WHAT IS A FAIR STANDARD FOR ICE CREAM?

R. M. WASHBURN

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Ice cream is very distinctively an American product, even though it was known in some form for several hundred years in Europe before it was introduced to this country. In Europe and during times past it bore slight resemblance to the mellow creamy uniform article of the present. Then, too, our people were the first to develop the wholesale manufacture of ice cream, to introduce ice cream parlors and in general to develop the ice cream habit. Before the world's disturbance ice cream might have been had in sea port towns in nearly every part of the world and on most ocean liners, and yet it was the American made product, taken chiefly from New York City. In other parts of the world ice cream is a kitchen product made where served, and varies in quality accordingly.

## AS A CONFECTION

Ice cream, until very recently, was classed as a confection along with candy and soft drinks and as such came close to being ruled out of business at the time of the greatest shortage of sugar, and it was fortunate indeed that food officials counseled with the ice cream manufacturers and others regarding the product, for then it was pointed out that, being made of cream, condensed milk and sugar chiefly, it possessed very definite food values.

## AS A FOOD

Critical analysis of ice cream revealed the fact that it possessed much of the same food properties as butter or cheese, which are made from the same general source, though naturally differing in its nutritive relation. In the past, ice cream (so-called) has been made from probably thousands of combinations of milk, cream, eggs, sugar and condensed milk, so that when the article first entered commerce it varied greatly in its value, and after

growing to considerable proportions seemed to demand a standard especially as to fat content. This was done to guarantee to the consumer that a proper amount of food nutriment might be obtained with a given purchase. The question was what the standard should be. One group of workers advised that the fat standard of ice cream should bear a definite relation to the fat standard in cream which was legal in the community in which the ice cream was made. This, however, seemed illogical to a few workers who believed that the fat content of ice cream should be governed by the product and its uses, rather than by the raw material from which it was made.

## BASED ON CREAM

The first fat standard for cream to gain general recognition was that advocated by the national pure food law which fixed 18 per cent fat as the minimum. Using this as a basis and reasoning that since the introduction of sugar into the cream in sufficient amount to make it palatably sweet, would dilute or reduce the fat content to nearly 14 per cent; that 14 per cent should therefore be considered as the legal minimum of fat for ice cream.

It is now generally recognized and recently sustained that the various states have the right to establish and enforce standards in food commodities. It is likewise established that cities of the first class have this right where such does not conflict with the state. Therefore, the fat standard of ice cream would become as variable as the cream standards in the several states and cities if ice cream were to be based upon cream. For instance, the legal standard of cream in Minnesota is 20 per cent, Wisconsin 18, and Iowa 16. Consequently the ice cream fat content should be about 17, 15 and 13, respectively. Consequently if a manufacturer located at, say Winona, La Crosse, or Decorah, shipped into three states named, he would either have to make three grades, keep them separate in his storehouse and in the shipping, which would be next to impossible, or he would have to put into all his cream enough fat to meet the highest requirement and be

very much handicapped in meeting the competition in the states requiring less fat. As between cities, we notice that 20 per cent fat in cream is demanded in Los Angeles, Portland, Spokane, Memphis, Minneapolis, and Washington, D. C., while 18 per cent suffices to satisfy Toledo, Syracuse, Seattle, Philadelphia, and New York, and 16 per cent is enough for Newark, N. J., Columbia, S. C., and Denver, Colo., but again we note that the ordinances of Chicago, St. Louis and Boston require but 15 per cent fat, with Beaumont, Texas, requiring only 13 per cent. In this medley of requirements we find a variation of nearly 50 per cent and upon what fact of life or need are they based? Indeed, we must believe that these standards were established as compromises of judgment or as the opinion of the dominating member of the council. Not only in scattered cities do we find discrepancies in fat standards of cream, but in cities within the same state. Thus, Spokane demands 20, Seattle 18; Boston 15, Fall River 16; Houston 18, Beaumont 13; Detroit 18, Flint 20; St. Louis 15, Kansas City 18. Again we can imagine the struggle any dealer would have trying to meet competition and at the same time live up to such a medley of requirements. Cities located in different states but close together offer an even more distressing possibility. Thus, Kansas City, Missouri, requires 18 per cent fat in cream, while Kansas City, Kansas, is satisfied with 16 per cent; St. Louis, Missouri, 15 per cent and East St. Louis, Illinois, 16 per cent.

Consistently carried out, therefore, the basing of the ice cream standard upon the cream standard for the state and city in question would introduce at best a useless confusion, unwarranted by any real need or good to be done.

## OTHER DAIRY FOODS

Other manufactured dairy foods are not dependent upon the composition of raw material for their standard, thus butter, whether churned from thin cream or thick cream, must not contain to exceed 16 per cent water, nor according to the United States Pure Food Law less than 82½ per cent fat. Likewise,

cream whether extracted from Holstein milk testing 3.4 per cent, Shorthorn testing 4 per cent, or Jersey testing 6 per cent, must contain the quantity of fat specified in the ordinances of the city in which it is sold, and this we have noted, varies in general from 15 per cent to 20 per cent. In general, about 20 per cent of the volume of milk is extracted as cream, but if this simple proportion were maintained, we would have Holstein cream testing from 16 to 17 per cent fat, and Jersey cream testing from 26 to 30 per cent fat. In my judgment the fat content of cream should be based upon the needs of cream, not upon the fat content of the milk from which it was derived, just as the acid content of vinegar should be 4 per cent in order that it may preserve pickles rather than based upon the sugar content of the apples from which it was made, or in the case of white wine vinegar, the per cent strength of alcohol from which it was made.

Non-uniformity of requirements is one of the exasperating features of interstate commerce and few, if any, articles are already more tangled as to state requirements than ice cream. This is shown by the following list of states, with the fat standard of ice cream stated:

| | |
|---|---|
| United States..... | No standard. All attempts to enforce circular 19, requiring, 14 per cent fat, have failed. |
| Alabama..... | 14 per cent by reference to United States |
| Arizona..... | 10 per cent for vanilla—8 per cent fruit, nut and chocolate |
| Arkansas..... | No standard. |
| California..... | 10 per cent and 8 per cent |
| Colorado..... | 14 per cent and 12 per cent |
| Connecticut..... | 8 per cent and 6 per cent |
| Florida..... | 12 per cent |
| Georgia..... | 8 per cent |
| Idaho..... | 14 per cent by reference to United States |
| Illinois..... | 8 per cent |
| Indiana..... | 8 per cent |
| Iowa..... | 12 per cent |
| Kansas..... | 14 per cent by reference to United States |
| Kentucky..... | 10 per cent and 8 per cent |
| Louisiana..... | 10 per cent and 8 per cent |
| Maine..... | 14 per cent by reference to United States |
| Maryland..... | 8 per cent and 6 per cent |
| Massachusetts..... | 7 per cent |

| | |
|---|---|
| Michigan | 10 per cent |
| Minnesota | 12 per cent |
| Mississippi | 8 per cent |
| Missouri | 8 per cent reduced in 1919 from 14 |
| Montana | 10 per cent reduced in 1919 from 14 |
| Nebraska | 14 per cent and 12 per cent bill now in legislature to reduce |
| Nevada | 14 per cent and 12 per cent |
| New Hampshire | 14 per cent |
| New Jersey | No standard |
| New Mexico | No standard |
| New York | No standard |
| North Carolina | 8 per cent |
| North Dakota | 10 per cent and 8 per cent |
| Ohio | No standard |
| Oklahoma | 10 per cent and 8 per cent |
| Oregon | 8 per cent and 6 per cent |
| Pennsylvania | 8 per cent and 6 per cent |
| Rhode Island | 8 per cent |
| South Carolina | 14 per cent by reference to United States |
| South Dakota | 14 per cent and 12 per cent |
| Tennessee | 8 per cent |
| Texas | 8 per cent |
| Utah | 14 per cent by reference to United States |
| Vermont | 14 per cent by reference to United States |
| Virginia | 8 per cent |
| Washington | 8 per cent |
| West Virginia | 8 per cent |
| Wisconsin | 14 per cent by reference, 2 per cent tolerance allowed |
| Wyoming | 10 per cent |
| Average | 10.54 (the 42 States having standards considered) |
| Canada | 10 per cent reduced from 14 about five years ago |

## ICE CREAM BASED ON OWN NEEDS

It is a fundamental law in the nutrition of animals of all species that three general classes of foods are needed, namely: ash for bone building, protein for muscle construction, and sugar, cellulose or fat for heat formation. Natural milk, which is universally conceded to be the most nearly perfect food, contains these various substances approximately in the proportions shown in table 1. Ash is present in minor but useful quantities. Sugar is present to the amount of about 4.88 pounds to 100 pounds of milk. Sugar does the same work as fat in the body, namely:

it furnishes energy for work and heat for warmth. Protein is the general name for casein, albumin, and the other minor similar substances. Its chief function is muscle building. Fat, about 3.69 pounds to the hundred, serves to produce heat, energy and fatness. The great difference between fat and sugar is that fat is 2¼ times more heating than sugar and is in general more difficult of digestion. Protein and sugar have heating powers practically identical. Therefore, by multiplying the fat content by 2¼ we have reduced it to the same terms as the other food nutrients, or, in other words, we have reduced the several substances to a common denominator and therefore can add them direct. Doing this, we find that the total starch value of 100 pounds of ordinary milk is about 16.43, or, in other words, 16.43

TABLE 1

*Composition of milk*

| | per cent | | per cent |
|---|---|---|---|
| Water | 87.17 | | |
| Solid | 12.83 | Ash | 0.71 |
| | | Sugar | 4.88 |
| | | Protein | 3.55 |
| | | Fat | 3.69 |
| Total starch value | | | 16.43 pounds |
| Total energy value | | | 29,804 calories |
| Nutritive ratio | | | 1:3.7 |

pounds of dry starch or wheat flour would be required to equal 100 pounds of milk of this grade. The heat or energy value of foods is measured in calories of which this food contains about 29,804. The proportion, or ratio, between muscle producing and the heat producing foods is called the nutritive ratio and in average milk is about 1:3.7. For comparison we may study the composition and value of 20 per cent cream as shown in table 2, which we find has a starch value equal to 52 pounds, a total energy value of 94,328 calories, thus indicating a richer food; but likewise, we must note that there are 16.3 times as much heating food as muscle making food in cream of this grade, or, in other words, the nutritive ratio is 1:16.3.

Evaporated milk furnishes an excellent comparison with cream since it contains so nearly the same amount of total solids,

namely about 27 per cent, but differs from the cream chiefly in having a much higher protein content and lower fat content. This is shown in the starch value of 35.87 as against 52 and in the total energy of 65,068, as against 94,328. The proportion of muscle to heating properties in evaporated milk is shown to be about 1:3.8, practically identical with that of normal average milk. In this substance we have then high solids without high heating.

TABLE 2

*Composition of 20 per cent cream*

| | per cent | | per cent |
|---|---|---|---|
| Water | 72.41 | | |
| Solids | 27.59 | Ash | 0.59 |
| | | Sugar | 4.00 |
| | | Protein | 3.00 |
| | | Fat | 20.00 |
| Total starch value | | 52.00 | pounds |
| Total energy value | | 94,328 | calories |
| Nutritive ratio | | 1:16.3 | |

TABLE 3

*Composition average evaporated milk*

| | per cent | | per cent |
|---|---|---|---|
| Water | 73 | | |
| Solids | 27 | Ash | 1.5 |
| | | Sugar | 9.7 |
| | | Protein | 7.5 |
| | | Fat | 8.3 |
| Total starch value | | 35.87 | pounds |
| Total energy value | | 65,068 | calories |
| Nutritive ratio | | 1:3.8 | |

The composition of what we may term "old fashioned" ice cream, as shown in table 4 reveals a comparatively low ash, low protein, and high fat with an energy value of 98,718 calories, indicating a rich food, but with a ratio of nutrients indicating more than 17 times as much heating as muscle producing food. By comparing this with table 5, showing the composition of modern ice cream, we note that the ice cream which has been made up in part by the use of condensed or evaporated milk, and contains, therefore, higher proteins and a lower fat content

has only about 85 per cent as much heat in it per pound as the old style compound, or in other words, the 14 per cent fat ice cream contains about 20 per cent more heat than does modern ice cream. While an examination of the ratio or proportion of nutrients in the modern indicates that there are only about six times as much heating as muscle producing food, or, in other words, the nutritive ratio of the modern ice cream is about 1:6.0 as compared to 1:17.1 in the old style.

TABLE 4

*Composition of "old fashioned" ice cream*

| | per cent | | per cent |
|---|---|---|---|
| Water | 63.75 | | |
| Solids | 36.25 | Ash | 0.55 |
| | | Milk sugar 4.00 / Cane sugar 14.20 | 18.20 |
| | | Protein | 3.00 |
| | | Fat | 14.50 |
| Total starch value | | | 54.42 pounds |
| Total energy value | | | 98,718 calories |
| Nutritive ratio | | | 1:17.1 |

TABLE 5

*Composition of modern ice cream*

| | per cent | | per cent |
|---|---|---|---|
| Water | 64.80 | | |
| Solids | 35.20 | Ash | 0.91 |
| | | Milk sugar 6.07 / Cane sugar 14.20 | 20.27 |
| | | Protein | 4.65 |
| | | Fat | 9.40 |
| Total starch value | | | 46.4 pounds |
| Total energy value | | | 84,142 calories |
| Nutritive ratio | | | 1:6.0 |

High fat ice cream is hot; that is, contains a large quantity of heat units compared with that containing less fat, and since it is a generally recognized principle that people in summer should consume less fats and more fruits and cooling foods, it is directly in line with the advice of the health bureaus, dietetic experiments and physicians to maintain that ice cream, which is consumed most largely in summer for its cooling effect, should be chemically cool while being physically cold. Therefore, the fat standard

for ice cream, based upon the needs of the people eating the ice cream, would be comparatively low, say 8 to 10 per cent.

In conclusion, it seems clear that (1) a standard for composition is needed, (2) the composition should be based upon the needs of ice cream as a food and not upon some standard for cream, and (3) a fat percentage of 10 per cent for plain vanilla ice cream and 8 per cent for fruit, nut and chocolate ice cream is sufficient for all useful purposes.

# TWO ORGANISMS OF A COMMERCIAL LACTIC STARTER

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It has become a more or less popular idea in this country that lactic starters consist of a single pure culture of a lactic acid producing organism, usually considered to be of the Streptococcus lacticus type. Nevertheless it has been recognized that not all pure cultures of this organism give the proper delicate flavor of a good starter.

In Europe, where the most extensive work on starters has been carried on, the general opinion seems to be that more than one organism is necessary for a good flavored starter. Storch (12) has shown that two types of organisms are concerned in a good starter; one a lactic acid producing organism and the other a type which was quite different but which when cultivated with the lactic type seemed to give the taste and flavor of a good starter. This flavor-producing type, which he called X bacteria, did not coagulate milk nor form much acid, but produced considerably more volatile acid than the lactic type. He also found that the lactic type produced a higher acidity when grown with the X bacteria.

Boekhout and De Vries (1) have isolated from sour milk and cream an organism which when grown with lactic acid producing organism of the *Streptococcus lacticus* type produced a characteristic and desirable aroma. This streptococcus resembled the lactic acid organism in morphology, but produced no visible change in milk.

Hammer and Bailey (6), while studying the volatile acid production in starters, found that cultures of the lactic acid producing type of organism, which they call B. lactis acidi, when isolated from starters gave a much lower volatile acidity in milk than did the starter itself. This they found to be true with a

number of commercial starters studied. After considerable difficulty they isolated an organism which, although it did not curdle milk, produced more volatile acid than did the lactic type. When grown with the lactic organism the volatile acidity was still further increased and also the total acidity. These two organisms which were isolated from the starter when grown in combination gave a volatile acidity similar to that secured from the starter itself. This work suggests that perhaps the commercial starters in the United States consist of more than one type of organism. It is possible that the volatile acid producing organism isolated by Hammer and Bailey is of the same type as the X bacteria described by Storch, and the aroma producing organism isolated by Boekhout and De Vries.

It is the purpose of this paper to describe two organisms isolated from a commercial starter which when grown together seem to reproduce the desirable characteristics of the original starter both in regard to activity and flavor.

## THE TOTAL AND VOLATILE ACIDITY PRODUCED BY THE ORIGINAL STARTER AND TWO CULTURES ISOLATED FROM IT

While engaged in an attempt to secure an active organism of the lactic type from a commercial starter, we found that while this was easily accomplished the culture did not give the delicate flavor of the original starter. This emphasized the fact that some other organism was of importance in connection with a desirable flavor. Plates were then made using a milk powder agar,[1] and the starter examined at different stages of its development during a twenty-four-hour period. The appearance of the plates showed that there were two distinct types of colonies. One type was surrounded by a small white zone, which on the milk powder medium indicates a high acid production. The other type of colony showed no such zone. The appearance of the paper by Hammer and Bailey (6) at this time led us to make determinations of the volatile acid produced by these two types

[1] Directions for the preparation of milk powder agar can be found in the Journal of Bacteriology, v, no. 6, 565–588.

of organisms, both of which were streptococci. These cultures were inoculated into sterile skimmed milk and incubated for twenty-four hours at 30°C. and then steam distilled. In order to make our results comparable to those obtained by Hammer and Bailey, we followed their method of steam distillation, using

TABLE 1

*Comparison of fermented milks prepared by the use of a commercial starter and two organisms isolated from it used separately and in combination*

| CULTURE | INOCULATION | ACIDITY, AS LACTIC ACID | VOLATILE ACID, CC. $\frac{N}{10}$ NaOH NEUTRALIZED. | EFFECT OF CULTURE ON MILK | FLAVOR |
|---|---|---|---|---|---|
| | | *per cent* | *cc.* | | |
| Commercial starter | 1 cc. 24-hour old culture to 350 cc. sterile skimmed milk | 0.82* | 25.1 | Firm curd, indication of little gas | Sharp pleasant acid, but delicate flavor |
| Culture "L" | 1 cc. 24-hour old culture to 350 cc. sterile skimmed milk | 0.86* | 7.0 | Firm curd, no gas | Sharp, clean acid flavor |
| Culture "A" | 1 cc. 24-hour old culture to 350 cc. sterile skimmed milk | 0.23 | 7.5 | Not coagulated, very little increase in acidity | Not sour |
| Combination of culture "L" and culture "A" | 1 cc. of each 24-hour old culture to 350 cc. sterile skimmed milk | 0.87* | 23.8 | Firm curd, indication of little gas | Sharp pleasant acid, but delicate flavor |

* The per cent of lactic acid varied and was often higher than in this particular experiment.

250 cc. of milk culture and titrating the volatile acid obtained from 1,000 cc. of distillate.

From the results shown in table 1 it will be seen that the commercial starter produced a total acidity of 0.82 per cent, calculated as lactic acid, and 25.1 cc. volatile acid, the volatile acid being expressed in terms of $\frac{N}{10}$ NaOH, neutralized by the volatile

acid in 1,000 cc. distillate from 250 grams of the milk culture. The culture showed a firm curd with *indication of a little gas* and had a sharp, pleasant acid but delicate, flavor.

Culture "L" was from one of the colonies on the milk powder agar plate which showed a white zone around it. This culture, when inoculated in sterile skimmed milk and handled in the same manner as the commercial starter from which it was obtained, gave an acidity of 0.86 per cent with a volatile acidity of 7 cc. of $\frac{N}{10}$ NaOH. The culture showed a firm curd with *no indication of gas* and had a sharp, clean acid flavor, but lacked the delicate flavor of the original starter.

The other organism, Culture "A," isolated from the starter from a colony showing no white area about it, was of considerable interest to us. It produced an acidity, in sterile skimmed milk, of only 0.23 per cent, calculated as lactic acid, and a volatile acidity of 7.5 cc. of $\frac{N}{10}$ NaOH. The milk was not coagulated and not sour to the taste.

When these two cultures "L" and "A" were grown together the results obtained duplicated the action of the original commercial starter, as will be observed from the figures in table 1. The volatile acidity was practically the same as that of the original starter, while there was a similar firm curd with an *indication of a little gas*. The soured milk, according to the opinion of several persons who examined it, had the same sharp pleasant acid, but delicate, flavor of the original starter.

## GAS PRODUCTION IN THE STARTER

It will be noted that in the original starter the appearance of gas was observed in the curd. A few gas bubbles could be seen on the side of the flask and often stripes in the smooth curd indicated the escape of gas at that point. In the dairy and the laboratory suspicion might be cast upon a starter showing this evidence of gas formation and the tendency would be to call it contaminated. This same gas formation, however, took place in the starter made from a combination of pure cultures "L" and "A." We were not at all surprised at this gas formation,

because it is known that gas formation by the streptococci is not uncommon. Freudenreich (5) found gas-forming streptococci in kefir, and Miss Evans (4) has shown that gas-producing streptococci of the Streptococcus kefir type are common in cheese, while Jensen (8) states that Streptococcus cremoris, which is commonly found in commercial starters, can develop such a quantity of carbonic acid that fine stripes appear in the curd. It has also been found in the course of our studies of the milk streptococci that $CO_2$ producers are very common in certain kinds of milk and from our knowledge of this type of organism, culture "A" rather than "L" was selected as the probable gas-forming organism.

TABLE 2

*Carbon dioxide production from 15 cc. of sterile skimmed milk inoculated with various cultures*

| MEDIUM | CULTURE "L" | CULTURE "A" | CULTURES "L" AND "A" | ORIGINAL COMMERCIAL STARTER |
|---|---|---|---|---|
| | cc.* | cc.* | cc.* | cc.* |
| Plain skimmed milk | 0.0 | 0.7 | 2.3 | 4.9 |
| Skimmed milk with 0.5 per cent peptone | 0.4 | 7.5 | 4.1 | 5.1 |

* Cubic centimeters of $\frac{N}{10}$ Ba $(OH)_2$ neutralized by $CO_2$. Determinations made in Eldredge tubes.

Experiments showed, as will be noted from table 2, that a little $CO_2$ was produced in skimmed milk by culture "A" alone and that it was greatly increased when grown with culture "L" which showed no $CO_2$ formation. In peptone milk $CO_2$ production was greatly stimulated by peptone, a fact which Miss Evans observed with Streptococcus kefir. The formation of $CO_2$ was determined by the use of fermentation tubes described by Eldredge and Rogers (3), and we highly recommend these tubes for the routine determination of small amounts of $CO_2$ produced by bacterial action.

It seems evident from these results that the indication of gas formation in a starter does not necessarily mean contamination. On the other hand, it may indicate the proper development of a type of streptococcus which is essential in a good flavored starter.

It is possible that cultures can be found which do not produce $CO_2$ but which may possess the other desirable features of the culture under discussion.

## CHARACTERISTICS OF THE CULTURES

### *Culture "L"*

*Colonies on milk powder agar.* Colonies are small but have a distinct white zone about them. This indicates high acid production.

*Morphology.* Twenty-four-hour old milk culture.

The organism is a streptococcus of medium size and ovoid in shape. Chains of 4 to 8 cells are commonly found and often chains up to 20 cells.

*Growth in litmus milk.* Grows rapidly and decolorizes the litmus often before coagulation. Grows at 10°C. After twenty-four hours at 30°C. in skimmed milk an acidity of about 0.86 per cent (as lactic acid) is reached.

*Fermentations.* Ferments dextrose and lactose. Does not ferment saccharose, salicin, mannite, raffinose, or inulin.

*Carbon dioxide production from milk.* Negative.

From the characteristics of culture "L," particularly its reducing action in litmus milk, its growth at 10°C., and the lack of ability to ferment saccharose, it seems evident that the culture belongs to the Streptococcus lacticus group. Sherman and Albus (11) have shown that the three characteristics mentioned are of importance in distinguishing the organisms of the Streptococcus lacticus type from other streptococci.

### *Culture "A"*

*Colonies on milk powder agar.* Colonies are small but do not show any white zone. This indicates little or no acid production.

*Morphology.* Twenty-four-hour old milk culture.

The organism is a coccus a little smaller than culture "L." It occurs frequently in chains of 4 to 8 and sometimes as high as 32 cells. The cells are ovoid in shape.

*Growth in litmus milk.* In twenty-four hours at 30°C. there is only a slight change in the color of the litmus. After seven days' incubation

the reaction is distinctly acid, but milk not coagulated. After twenty-four hours at 30°C. in skimmed milk an acidity of about 0.23 per cent (as lactic acid) is reached. The culture grows slowly in milk at 10°C. In skimmed milk with 0.5 per cent peptone an acidity of about 0.47 per cent is produced in twenty-four hours.

*Fermentations.* Ferments dextrose and lactose. Does not ferment saccharose, salicin, mannite, raffinose, or inulin.

*Carbon dioxide production from milk.* Positive.

Culture "A" did not grow in any of the ordinary media commonly used for fermentation tests. It was found, however, that the addition of casein to an extract peptone solution gave a medium which supported growth when a sugar was present which could be fermented. The composition of the medium was as follows: 0.5 per cent Fairchild peptone; 0.3 per cent meat extract; and 0.1 per cent casein, reaction pH 7.5. The casein solution was prepared by dissolving 5 grams of Hammarsten casein with 1 gram of sodium dibasic phosphate (Sorenson's phosphate $NA_2HPO_4 + 2H_2O$) in 100 cc. of distilled water. Enough of this solution was added to the medium to give 0.1 per cent of casein.

Culture "A" resembled the gas-forming streptococcus found by Freudenreich (5) in kefir and called by him Streptococcus B, which Migula (10) has named Streptococcus kefir. It agreed in most respects with the strains of Streptococcus kefir isolated from cheese by Miss Evans (4) but differed so far as it did not ferment saccharose and seemed to grow in artificial media with more difficulty. It was further observed by Miss Evans that the Streptococcus lacticus type of organism produced about 0.12 grams of acetic acid in milk while one of the Streptococcus kefir cultures produced 0.97 gram per 3,000 cc. of milk containing 0.5 per cent peptone.

It was found that, when grown in skimmed milk with 0.5 per cent peptone for seven days at 30°C., culture "L" (Streptococcus lacticus) produced about 0.32 gram of acetic acid per liter, while culture "A" produced about 1.1 grams of acetic acid and a small amount of propionic acid.[2] The acetic acid of a control flask

[2] We are indebted to Mr. McNair of these laboratories for these determinations.

of medium was not determined, but as the medium was the same in both cases, the results can be compared.

With our present knowledge of the two cultures it seems safe to say that culture "L" represents a strain of the Streptococcus lacticus type and culture "A" a strain of the Streptococcus kefir type.

## THE ASSOCIATIVE ACTION OF THE CULTURES

The associative action of bacteria is extremely interesting. Marshall (9) and his associates have made extensive studies of this subject, while Hammer (7) and also Buchanan and Hammer (2) have observed associative action.

TABLE 3

*Effect of peptone in milk on the activity of Culture "A" as shown by the examination of twenty-four-hour old cultures at 30°C.*

| MEDIUM | ACIDITY AS LACTIC ACID | VOLATILE ACIDITY, CC. $\frac{N}{10}$ NaOH NEUTRALIZED BY 1000 CC. DISTILLATE FROM 250 GRAMS OF CULTURE | BACTERIA PER CUBIC CENTIMETER AFTER INOCULATION | BACTERIA PER CUBIC CENTIMETER AFTER 24 HOURS INOCULATION AT 30°C. |
|---|---|---|---|---|
| | *per cent* | *cc.* | | |
| Skimmed milk* | 0.23 | 7.5 | 346,000 | 85,000,000 |
| Skimmed milk and 0.5 per cent peptone* | 0.47 | 37.1 | 163,000 | 311,000,000 |

* Inoculated with 1 cc. of a twenty-four-hour old culture to 350 cc. of medium.

Hammer and Bailey (6), in their study of commercial starters, isolated two organisms which in combination gave a volatile acidity similar to that of the original starter. Each of these cultures alone, however, gave a volatile acidity considerably below that of the original starter. They also found that the acidity, calculated as lactic acid, was increased by the associative action. A similar increase was observed by Storch (12).

As has been shown the two organisms under discussion in this paper acted in a similar manner so far as volatile acidity was concerned, and the associative action was plainly evident. We did not find that the acidity calculated as lactic acid was increased to any extent.

A few experiments which were tried throw some light on the increase in volatile acidity. From the results in table 3 it may be seen that when 0.5 per cent peptone was added to skimmed milk the acidity was about doubled and the volatile acidity increased about five times. The bacterial growth was also much more rapid as is shown by the bacteria counts on milk powder agar.

It is seen therefore that associative action with culture "L" (Streptococcus lacticus) was not necessary to increase the volatile acidity when peptone was added to the milk. Evidently the skimmed milk did not contain a readily available source of nitrogen for culture "A," which was supplied by the addition of a small amount of peptone. On this theory it may be possible to explain the associative action of the two cultures by assuming that through the growth of culture "L" the complex nitrogenous material of the milk was converted into lower forms which were more desirable sources of nitrogen for culture "A." The growth of this organism was therefore stimulated and the volatile acidity increased.

## SUMMARY

1. Two cultures of streptococci were isolated from a commercial starter. These two cultures seemed to be necessary in order to reproduce acidity and flavor of the original starter.

2. One culture was evidently a strain of the Streptococcus lacticus group. It produced a high acidity in milk and but little volatile acidity.

3. The other culture seemed to correspond to organisms of the Streptococcus kefir type. It produced but little total acidity in milk and when grown with the Streptococcus lacticus culture produced considerable volatile acid.

4. Gas was observed in the original starter. This was undoubtedly due to the growth of the organism of the Streptococcus kefir type, since when grown with the Streptococcus lacticus culture there was a gas formation similar to the original starter. It was further observed that carbon dioxide was formed by the culture when grown in peptone milk.

5. Associative action between the two cultures was very noticeable. The results indicated that the Streptococcus lacticus type through its growth converted the nitrogenous material of the milk into a form more available for the Streptococcus kefir type and as a result the growth of the latter was increased.

6. The results reported represent a study of only one commercial starter. It remains to be determined whether the cultures are the same in all starters.

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# HISTORICAL NOTES ON COTTON SEED AS FOOD[1]

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## THE USE OF COTTON SEED

Commercial utilization of cotton seed dates back to the middle of the nineteenth century, when the oil was first successfully expressed. Up to that time the cultivation of the cotton plant was for the cotton alone, the seeds being left to decay and yield fertilizer. One of the very early attempts to make use of the oil from the cotton plant was that of the Antilles of the British West Indies (Du Tertre, 1667) who made oil from the flower of the cotton plant and used it as a medicament for old ulcers. It was one hundred years or more before people began to investigate the various oleaginous seeds and to devise methods for dividing them into the oil and the oil cake. One of the first endeavors was that of the Moravians (Bishop, 1866) at Bethlehem, Pennsylvania, who, in 1769–1770, gave exhibits of specimens of oil which they had made from various oleaginous seeds. Among the exhibits was a sample of cotton seed oil that they had expressed from the decorticated seeds at the rate of nine pints of oil to a bushel-and-a-half of seeds. At the same time a sample of the oil was presented to the American Philosophical Society for the purpose of emphasizing the worth of the cotton seeds in their oil content.

The value of the residue, after the oil had been expressed from the cotton seed, next became of interest, especially to the agriculturist. The Royal Society of Arts of London (1783) was the first organization to foresee the true value of the cotton seed cake; and in the proceedings of that society for 1783 there is the following offer:

[1] Parts of this paper were taken from the dissertation submitted by Icie G. Macy for the degree of Doctor of Philosophy, Yale University, 1920.

The society being informed that a considerable quantity of oil can be obtained from Seeds of Cotton, and that after the expression of the oil, the remaining cake will afford a strong and hearty food for cattle; and likewise, that the apparatus for the operation can be applied to the mill for sugar canes, and worked in the rainy season, at a moderate expense; have resolved, for the foregoing reasons, that the procuring oil from the Seed of Cotton is a proper object of a premium, considered as an encouragement for planters to the cultivation of cotton, an article essentially requisite to increase manufacture of that commodity in this country.

The society therefore offers as follows:

*Oil from cotton seed*

To the planter in any of the British islands of the West Indies, who shall express oil from the Seed of Cotton, and make from the remaining seed hard and dry cakes, as food for cattle; the gold medal.

*Certificates* that not less than one ton of the oil has been expressed, and five hundred weight of the cakes obtained, to be produced to the society, with two gallons of the oil, and two dozen of the cakes, together with a full account of the process, on or before the last Tuesday in November, 1785.

For the next greatest quantity, not less than half a ton of oil, and two hundred weight of the cakes; the silver medal.

The premiums were annually renewed for six years but the large quantity required appears to have defeated the object, as no awards were made. In 1785 a similar premium was offered in this country by the South Carolina Agricultural Society (Bishop, 1886). Nevertheless, it was not until 1819 that a patent was taken out for the preparation of cattle food from cotton seed, and in the following year another was taken out for the extraction of oil from the same seed. As a matter of fact the oil was not expressed on a commercial scale until the middle of the nineteenth century and since then the growth of the industry has been phenomenal, particularly in America. A new source of profit to the southern cotton planter has been founded in the manufacture of cotton seed oil and pressed seed cake from

many tons of seeds which had before been valuable only as fertilizer.

The cotton seed cake from which the oil has been expressed contains all of the fiber and mineral matter of the seed, the residue of oil or fatty material not extracted, and, what gives it special value, the nitrogenous constituents. It is stated that one short ton of cotton seed, constituting about 40 per cent of the raw cotton, will yield 800 pounds of cotton seed cake and 45 gallons of crude cotton seed oil.

After the introduction of cotton seed meal on the market for feeding live stock, attention was next directed to the possibilities of decorticated cotton seed meal as a food for human beings by the late Colonel J. W. Allison, one of the pioneers of the cotton seed oil industry in the United States. He put cotton seed flour on the market as an article of food for human consumption in 1876. Since cotton seed flour contains little or no starch but about 54 per cent of crude protein it has been prescribed in medical cases where a starch-free diet is necessary, and has been used to some extent as a diluent for wheat flour. Experiments on the dietetic value of cotton seed flour for human beings have not been carried out for sufficiently long periods of time to enable final conclusions to be drawn.

### *Preparation of cotton seed products*

The cotton seed *kernels* are obtained by decorticating the whole cotton seeds and freeing them from most of the hulls and lint. After the greater portion of the oil has been expressed from the kernels, a product known as the cotton seed *press cake* is obtained. This contains all the crude fiber and mineral matter of the seed, the residue or the fatty material not extracted, and a large quantity of nitrogenous constituents. The press cake is available in slab form, or is cracked coarsely or finely, or ground into *meal*. The *meal* is put through an intricate process of refining and bolting to produce the cotton seed *flour*.

Two processes are commonly used in the preparation of cotton seed meal. The so-called "cold pressed" meal is made by passing

the decorticated kernels through pre-heaters surrounded by steam under pressure. The dry kernels are then ground up in a screw press to express the oil. In this procedure, heat is generated, owing to the great amount of friction in the grinding. In the second process, after the whole kernels have been decorticated and crushed, the kernels themselves are subjected to steam pressure for about thirty minutes. After this treatment they are then emptied into the "cake former" where the oil is expressed and the residue pressed into cakes. According to Withers and Carruth (1918b), the actual temperatures in the hot and cold processes do not differ greatly. The cold pressing is really a dry pressing rather than a moist pressing.

*The problem involved in the feeding of cotton seed meal*

As soon as the oil from the cotton seeds was expressed in commercial quantities, the residual oil cake was put on the market in vast quantities as a cheap food for cattle, hogs, sheep, and other domestic animals. Although this commodity has been used in the south for many years, it is only within recent years that use has been made of it in the north and west. In the past a very large proportion of the cotton seed meal produced in America has been exported. The European feeders were the first to show their appreciation of this concentrated foodstuff as a food; for they were willing to purchase it in this country and pay freightage to Europe in order to have it for feeding purposes. However, when the farmers began using cotton seed meal in large quantities difficulty was encountered; the mortality of certain species of animals was increased owing to the so-called "cotton seed meal injury."

The first published notice dealing with the injurious effects of cotton seed meal seems to have been reported in England by Voelker in 1859 (Crawford, 1910). Since that time many cases have been reported, and for the past forty years vigorous attempts have been made to ascertain the direct cause of "cotton seed meal injury" and its effect upon the animal organism. Owing to the variability of effects on animals consuming similar amounts of cotton seed meal, the tardiness in appearance of abnormal

symptoms in some cases, and the lack of consistently uniform results, compatible studies are difficult.

Numerous experiments have been conducted on swine; of all the farm live stock these animals are the most sensitive to the deleterious effects of cotton seed meal. In the light of our present knowledge, hogs may be allowed to eat small quantities for short periods of time with profit, but it is never advisable to feed growing pigs as a rule on cotton seed meal.

Among individuals of the same species of animals there is the most notable variation in the effects of cotton seed meal upon the animal organism. This is particularly true in the case of cattle. Milch cows during lactation may feed for prolonged periods upon this foodstuff without any deleterious effects; steers will fatten for a short time, but if the period is prolonged injury results; and many deaths result among young calves. Dinwiddie and Short (1911) report that cows as well as other live stock possess a relative immunity during lactation. However there has been no solution to the problem which will explain the difference between susceptibility of fattening cattle and young calves. Tietze (1893) found that calves from nine to twelve months are most susceptible. The more recent investigators advise that cotton seed meal should be fed very sparingly and with extreme caution to young calves until more is learned concerning its toxicity. Sheep are less sensitive to the ill effects of cotton seed meal. Gray and Ridgeway (1910) report feeding large amounts to sheep with few fatalities. Other investigators have had similar experiences.

The results of experimenters in feeding cotton seed meal to poultry are very diverse. However, the consensus of opinions is that it should never be fed in large quantities. Opinions differ as to its effect upon pullets developing and coming to laying maturity, the effect upon egg production, and the loss of flesh. Ahrens (1917) reported the mortality of chicks very high on both normal and excessive cotton seed meal rations. However, our knowledge is very limited as to exact cause of such results.

Cotton seed meal is most actively toxic to rabbits and guinea pigs, as shown by a large number of investigators and also by

this author whose data are yet unpublished; while the same sample may or may not be injurious when fed to mice and rats. No human fatalities have resulted from the use of cotton seed flour in so far as I am able to ascertain, perhaps due to a low content of the toxic substance gossypol which will be discussed later, or because it has not been eaten for long enough periods of time or in sufficient amounts to enable final conclusions to be drawn as to its dietetic value or possible harmful qualities. Since experiments with cotton seed meal on lower animals reveal such deleterious properties, it would appear wise to use cotton seed flour sparingly until our knowledge regarding the whole problem of cotton seed meal injury has been more satisfactorily investigated than it has at the present day.

## SPECULATIONS AS TO THE CAUSES OF COTTON SEED MEAL INJURY

### *Review of previous work*

Our knowledge is very limited as to the causes of cotton seed meal poisoning although it has been a subject for investigation for many years. One of the earliest attempts to solve the problem was made by R. Böhm (1881) who, in 1881, discovered cholin in cotton seed and was the first to suggest the poisonous nature of this compound in cattle food prepared from cotton seeds. He states having received from a druggist an alcoholic extract from a cattle food prepared from cotton seed which had been fed as a diet to young cattle in Germany and had proved fatally poisonous. From this alcoholic extraction a large preparation of cholin was made, and Böhm concluded that only one base was present. Nevertheless one year later, in 1882, Ritthausen and Weger (1884) succeeded in obtaining a very large yield of betaïn. Although betaïn is nonpoisonous, as was pointed out by Gaehtgens,[2] in 1870, investigators (Wiley) suggested that cholin is the original base formed and betaïn is a secondary product, and they presumed that in all cases of cotton seed

[2] Gaehtgens, Dorpater medicin. Zeitschr., 1870, Bd. i.

meal poisoning a meal had been fed in which cholin was relatively more abundant than betaïn.

Maxwell (1891) reported a more extensive study of these nitrogenous bases, the object being to learn their relative proportions in cattle food prepared from cotton seeds and to study the physiological effects of cholin. He estimated the mixed chlorides of cholin and betaïn as 0.24 per cent and the proportions of the two bases as 17.5 and 82.5 per cent, respectively. In experiments on cats, Maxwell (1891) found that 0.3 gram of the cholin which he had prepared from cotton seed was sufficient to paralyze a strong cat and that 0.5 gram would produce immediate death.

It has since been shown that cholin does not exert a poisonous action upon animals when fed by mouth; however, when injected subcutaneously it has toxic properties. Moreover the toxic action of cotton seed meal does not induce the clinical symptoms and pathological lesions that correspond to the poisonous action of cholin. As a matter of fact, Von Hoesslin (1906) reported a series of experiments in which he found the chlorate of cholin much more toxic than the cholin alone; furthermore 2 grams of cholin hydrochlorate could be fed by mouth to rabbits with no serious results. Thus the quantity of these compounds found in cotton seed meal is far too small to account for the toxicity of the various cattle foods.

Brieger (1886) suggested the possibility of cholin decomposing into neurin, a toxic compound, but was unable to demonstrate such a conversion. Modrakowski (1908) likewise was led to a similar conclusion. Basing his theory on a series of experiments in which he found freshly prepared cholin to be less toxic than old cholin concluded that the symptoms of cotton seed meal poisoning result from ptomaines which have a neurin- or a muscarin-like action. Friemann (1909) similarly reported that ptomain substances are probably formed from the nitrogen-containing components of the lecithin in the meal. He also suggested that unsaturated fatty acids present in the fat extracted from cotton seed meal have some relation to the sum total of the toxic action.

An investigation of cotton seed meal with regard to its high protein content was made by Tietze (1893). In the summer of 1893 he investigated several cases in which the death of young calves was attributed to the use of cotton seed meal and found that the calves received 3 heaping liters of this meal in addition to skim milk, hay and linseed cake. The trouble was believed to be due to the high protein content of the cotton seed meal.

A belief is also prevalent that the harmful effects of cotton seed meal as a feeding stuff is due to the fibers therein, and that they sometimes cause great trouble in animal feeding by obstructing the intestinal tract. The amount of fibers in this particular feed may vary from 2 to 25 per cent. However, no cotton fibers have been found on autopsy in the intestine of the animals which have died of cotton seed poisoning.

The findings of Namêche (1900) on young cattle, rabbits, a goat, cow, and pigs led him to conclude that cotton seed meal in itself was not harmful, but that the poisonous properties are due to carelessness on the part of the feeders, ignorance in the use of cotton seed meal, or a lack of cleanliness.

Other speculations were made by Zopf (1882) and Von Nathusius (1885). From their work they attributed the poisonous action of cotton seed meal to parasitic organisms found in the meal. Edgerton and Morris (1912) have fed cotton seed meal infected with molds that usually grow on the cotton plant to rabbits, and guinea pigs, and found that such parasites do not increase the toxicity of cotton seed meal.

In 1903 König, Spickermann, and Olig reported a very complete study on the decomposition products of cotton seed meal by different sorts of microorganisms. They found that all the organisms investigated gave similar physiological effects, were affected by the composition of the meal, and by the air supply. All the bacteria that attacks the proteins of cotton seed meal cause the following cleavage products; albumose, peptone, amines, volatile fatty acids such as butyric and valeric acids, aromatic acids as phenylacetic and phenylpropionic acids, succinic acid, skatolcarbonic acid, aromatic oxyacid, indol, skatol,

phenol, ammonia, carbon dioxide, and volatile sulphur compounds. However, at no stage of decomposition of cotton seed meal, the authors conclude, were poisonous substances formed by bacteria commonly present as shown by physiological experiments.

Barnett (1909), in studying the effect of cotton seed meal fed in large quantities to dairy cattle, obtained results which point to the fact that this material contains a specific toxin affecting, firstly, the lymphatic glands draining the digestive tract, and secondly, the lungs.

The injury resulting from the feeding of cotton seed meal has been attributed to oil content. Lendrich (1908) found that rabbits became emaciated when cotton seed meal was administered daily. Even though Cowie and Munson[3] alleged that the administration of oil interfered with digestion in man, this alone could not explain the toxicity of cotton seed meal. Alsberg and Schwartze (1919) in their recent pharmacological studies of gossypol, a phenolic compound found in cotton seed, administered this compound in oily solution by stomach tube to rats. Even small doses were fatal; for the animals died a few days later. Post mortem examination revealed the fact that both the oil and the gossypols still remained in the stomach, for both were re-isolated. Evidently either the oil or gossypol or perhaps both interfered with digestion. Gossypol will be discussed at length later in the paper.

Many speculations have been made as to the poisonous action of the compounds of phosphorus contained in cotton seed meal, inasmuch as phosphorus is such an important constituent, as has long been recognized. In 1890 Dancy (1890) called attention to the fact that phosphoric acid acted differently from orthophosphoric acid.[4] This was followed up by Harding (1892) who suggested that some of the peculiar, and in certain cases injurious and even fatal effects produced by the use of cotton seed and cotton seed meal as feeding stuffs may be due, in a

[3] Cowie, D. M., and Munson, J. F. Archives Internal Med., 1908, i, 61.

[4] Starkenstein, Biochem. Zeitsch., 1911, xxxii, 243, has demonstrated that orthophosphoric acid to be only slightly toxic.

measure at least, to the presence of meta- and pyro-compounds,[5] but no experimental data are given to ratify his belief.

Crawford (1910) in studying the toxicity of cotton seed meal on rabbits concluded that the chief poisonous principle is a salt of pyrophosphoric acid. The fact that some meals are more toxic than others was thought to be due to the conversion of ortho- into the meta- and pyrophosphoric acids by the heat during the process of manufacture.

Other investigators reported experiments to prove that the phosphoric acids are not the cause of cotton seed meal injury. In a series of investigations which extended over a period of two years, Edgerton and Morris (1912) found no evidence whatsoever that pyrophosphoric acid had anything to do with the poisoning. In the same year Rather (1912), after a study of the forms of phosphorus in cotton seed meal by various extraction processes, stated that there is no evidence that cotton seed meal injury is due to either pyro- or metaphosphoric acids.

Withers and Ray (1913) conducted an extensive series of experiments in which particular attention was laid on the phosphoric acid content. Rabbits were fed cotton seed meal, aqueous extracts, pepsin-pancreatin digestion products, residue after ammonium citrate extraction, and finally amounts of pure sodium pyrophosphate corresponding to that in the cotton seed meal. These investigators found that the pepsin-pancreatin extract is non-toxic to rabbits under ordinary conditions of feeding. The residue undigested by pepsin-pancreatin is more toxic than the material made soluble by digestion and is definitely harmful when fed in normal amounts. A meal may prove to be poisonous upon experimentation but still contain a non-toxic amount of the pyrophosphoric acid salts. This investigation proves quite conclusively that under ordinary conditions, the pyrophosphoric acid is not responsible for the toxicity of cotton seed meal.

[5] Gamgee, Priestley, and Larmuth, Jour. Anat. and Phisol., 1876, ii, 255, had previously demonstrated that sodium meta- and pyro- phosphates were very toxic to rabbits when injected into the animal but not toxic when fed by mouth. This was later corroborated by Schultz. Arch. Exper. Pathol., 1884, xviii, 174.

The work of Withers and Ray (1913) was corroborated by Symes and Gardner (1915) in their study of the toxicity of sodium pyrophosphate administered in food to rabbits, rats, and cats. Cotton seed meal proved fatal to rats when fed as an exclusive diet; even 5 grams of cotton seed meal per head daily supplemented with oats and bran were fatal; similarly meal after previous extraction with alcohol and ether, fed with oats and bran caused death, though not so early. The $P_2O_5$ content of the cotton seed meal amounted to 0.022 gram in the daily ration, a quantity which corresponds to 0.07 gram of sodium pyrophosphate, less than one-seventh of the quantity tolerated by rats which consumed daily 0.5 gram per head of crystalline sodium pyrophosphate for a period of 9 weeks without harm. The experimenters (Symes and Gardner, 1915) concluded that since the toxicity can be reduced by extraction with alcohol and ether and the phosphate is present in such small quantities the chief poison of the meal is not pyrophosphate.

Anderson (1912) described the isolation of an unidentified phosphoric acid from cotton seed meal and its decomposition into inositol and phosphoric acid when heated in a sealed tube. The aqueous solution of the free acid gave all those reactions which have been attributed previously to the presence of pyro- and metaphosphoric acids in cotton seed meal. When it was given in 0.5 and 1 gram doses to rabbits symptoms of distress were produced, but the animals recovered their normal appearance in two or three hours. There is no conclusive evidence that this particular phosphoric acid is the cause of cotton seed meal injury.

In 1915 two theories arose, firstly, that cotton seed meal poisoning is a deficiency disease, as set forth by Rommel and Vedder (1915) and later supported by Wells and Ewing (1916); secondly, that it is due to a definite phenolic compound, gossypol, found in cotton seed meal, as shown by Withers and Carruth (1915).

*Is cotton seed meal injury a deficiency disease?*

Rommel and Vedder (1915), basing their conclusions upon the similarity of post mortem observations on pigs that died of

cotton seed meal poisoning with those of beriberi on man, believe "that the so-called cotton seed poisoning of pigs is a deficiency disease, analagous to the disease known as beriberi in man, if not identical with it. Acute cotton seed poisoning corresponds to wet beriberi, and the chronic form to dry beriberi. The cause of the so-called cotton seed poisoning is probably a deficiency in the ration." These investigators fed pigs upon polished rice, a ration deficient in vitamine, and a disease resembling beriberi in man resulted. They believe that pigs develop this deficiency disease as do human beings, but much more quickly. The symptoms and post mortem observations on the pigs that had died on the polished rice were very similar to those that had died of cotton seed meal poisoning. The following explanation of the condition was offered:

> The grain with which the cotton seed meal is most frequently combined is corn. Corn is notoriously deficient as a single feed for animals, and it must be properly balanced to be fed satisfactorily. The excellent results in feeding pigs which can be obtained from rations of corn meal and skim milk or other animal products, such as tankage, blood meal, fish meal, etc., are out of all proportion to the facts indicated by the conventional chemical analyses of protein, carbohydrate, and fat. When corn meal is fed with cotton seed meal, a combination is made of two feeds both of which are deficient.

The writers do not commit themselves further as to what component is lacking in cotton seed meal.

Wells and Ewing (1916), after feeding diets of cotton seed meal with sugar, starch and a little milk to very young pigs, concluded that the meal was an incomplete food; expressed in their own words,

> This is true even when it is fed with sugar and starch to a wide nutritive ratio. Pigs upon an absolute maintenance diet ate in addition only small quantities of cotton seed meal and were not injured by it. So-called cotton seed meal injury is due in large part to inadequate diet.

### *Gossypol, a toxic substance in cotton seed*

Kuhlmann (1861) showed that cotton flower as well as other portions of the cotton plant contained a yellow dye which, by action of acids, is converted into the so-called "cottonseed blue."

This was further examined by Marchlewski (1899) who isolated a crystalline product by purifying the phenolic constituents of cotton seed oil by repeated fractionation from acetic acid solution. To this golden crystalline substance, he gave the name gossypol, on account of its source and phenol properties. It dissolves in ordinary fat solvents. Withers and Carruth (1915) have isolated it from cotton seed kernels and found it to be very toxic to rabbits, rats, guinea-pigs, and pigs whether fed in the form of gossypol acetate, crystalline gossypol, or gossypol-containing extract. The same investigators (1918a) found that cotton seed kernels contain about 0.6 per cent gossypol; ether extraction renders the kernels non-toxic to rats and gives a highly toxic extract containing about 2 per cent gossypol.

Gossypol is quickly oxidized in solution of sodium hydroxide as shown by Marchlewski (1899) and later corroborated by Withers and Carruth (1915). The latter experimenters state that alcoholic-alkaline treatment very greatly diminishes, if it does not entirely remove, the toxic properties of cotton seed meal, owing to the oxidation of gossypol into a non-toxic substance.

Carruth (1918) in his work on the chemistry of gossypol, was able to isolate only very small traces of gossypol, as such, in certain cotton seed *meals*, yet the food products were definitely injurious to rabbits and pigs, but he isolated an oxidized product which he called "D" gossypol, the source of which is explained by the fact that during the process of manufacture of the meal from the kernels, gossypol is converted into "D" gossypol. This modified form is toxic to rabbits and swine but has little action on rats. Here a conspicuous feature of indefiniteness and unlike response of different species arises. Why should rabbits and swine not only respond to the gossypol in the kernels but also to the altered gossypol in the cotton seed meal, while rats are not affected by the latter? Many attempts have been made to render cotton seed meal non toxic, but none have been successful for all species alike. Withers and Ray (1913) found that boiling with alcoholic alkali was the most successful method of

treatment. This seems to be the only process out of a large number that rendered the meal harmless.

Withers and Brewster (1913) fed iron salts, copperas and ammonium citrate with cotton seed meal and found that the toxic factor was more or less inhibited in the case of rabbits and swine. After eliminating the toxic factor their results show no evidence of nutritive deficiency in cotton seed meal great enough to produce failure in a relatively short period.

By thus controlling the toxic factor, it is shown that cotton seed injury is not due to a lack of "vitamines" or to deficiency in calcium, sodium, and chlorine.

Heat under various conditions and temperature has been used as a detoxicating agent; moist heat at high temperature being the most satisfactory method up to the present time for rendering cotton seed less harmful. In general the toxic properties are rendered less injurious by heat, but as yet no method has been devised in which meal has been made entirely harmless to all species alike.

The most recent report on gossypol is by Alsberg and Schwartze (1919) who studied its pharmacological action after injection into cats, rabbits, and rats. They found that death from this substance was either due to circulatory failure, pulmonary edema, or cachexia and inanition. However, the action of the isolated gossypol deserves further investigation.

*Variations in effects from cotton seed foods*

The results of investigators in their studies of cotton seed foods are not constant owing in part to the notable variations in effects upon live stock; even animals of the same species respond at different times with unlike symptoms although they consume similar quantities of the same food. Other difficulties are encountered. The degree of toxicity of cotton seeds depend upon the variety of seed, and upon the climate and soil in which they are grown. And again, the meal, made from the kernels, is greatly altered by the treatment in the process of manu-

facture. There is uncertainty as to the degree of the responsibility of gossypol for the toxicity, as results of investigators differ. All such factors lend difficulty to the study of the effects of cotton seed foods and render the present status of the problem uncertain.[6]

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# DAIRY NOTES

J. W. HENDRICKSON

*University of Nebraska, Lincoln, Nebraska*

## RESIGNATIONS

Prof. J. H. Frandsen, for the past ten years in charge of the department of dairy husbandry of the University of Nebraska, resigned March 1 to become dairy editor and counsellor for the Capper Farm Press of Topeka, Kansas which includes the following publications: Kansas Farmer and Mail and Breeze, Missouri Ruralist, Nebraska Farm Journal, Oklahoma Farmer, Field and Farm, Capper's Farmer. Professor Frandsen will continue his residence at 1401 North 33rd Street, Lincoln, Nebraska.

Before coming to Nebraska, Mr. Frandsen was professor of dairying at the University of Idaho and previous to that time had been engaged in commercial work.

Nebraska's Dairy Department has made very marked progress during the past ten years. It is now housed in what is considered one of the best and most completely equipped buildings in the country. The dairy herd has reached a stage of development in production that has reflected much credit upon the entire institution.

Dr. Roscoe H. Shaw, after fourteen years of service, has resigned as research chemist of the United States Dairy Division in Washington, D. C., to accept the position of chemist and manager of the scientific department of Louis F. Nafis, Inc., of Chicago, manufacturers of scientific glass apparatus for testing milk and its products.

He has held positions on the faculties of the University of Wisconsin (where he was assistant to Dr. Babcock), the Kansas Agricultural College and the University of Nebraska.

Dr. Shaw is the inventor of several tests used in the dairy industry; the best known of these is the Shaw fat test for determining the percentage of fat in butter, others being a special purpose lactometer for use in calculating total solids in milk and a rapid acidity test for grading milk.

## DAIRY DIRECTORY

In collecting dairy notes of interest to the readers of the JOURNAL OF DAIRY SCIENCE, a letter was mailed to each department of dairy hus-

bandry in the United States asking for a list of the instructional staff of each institution. From these replies we are pleased to submit the following summary, which is incomplete in total of dairy departments and some of the missing details. Errors may not be always avoided and if any have been made in this summary we will be glad to stand corrected.

Should the readers of the JOURNAL be interested in continuing this as a condensed directory, it may help to know who's who in dairying.

ALABAMA

*Experiment Station, Auburn, Alabama*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Eaton, W. H..... | | | B.S. | 3 |
| Baker, K. G..... | | | B.S. | 2 |
| Burns, F. W..... | | | B.S. | 3 |
| Burleson, G. L..... | | | B.S. | 3 |
| Lauderdale, A. A..... | | | B.S. | 1 |
| Grimes, J. C..... | | | M.S. | 1 |

ARIZONA

*College of Agriculture, Tucson, Arizona*

| | | | | |
|---|---|---|---|---|
| Cunningham, W. S... | Professor | | B.S. | 7 |
| Davis, R. N..... | Assistant professor | | B.S. | 1 |
| Burrows, J. F..... | Fellow assistant | | | 2 |

ARKANSAS

*College of Agriculture, Fayetteville, Arkansas*

| | | | | |
|---|---|---|---|---|
| Dvorachek, H. E..... | Professor | | B.S.A. | 6 |
| Mason, R. H..... | Assistant Professor | | B.S.A. | 3 |

CALIFORNIA

*State University Farm, Davis, California*

| | | | | |
|---|---|---|---|---|
| Roadhouse, C. L..... | Professor | | D.V.M. | 4 |
| Turnbow, G. D..... | Assistant professor | | B.S.A., M.S. | 1 |
| Marquardt, J. C..... | Instructor | | B.S. | 4 |

COLORADO

*State Agricultural College, Fort Collins, Colorado*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Morton, Geo. E..... | Professor | Head of department animal husbandry and state dairy commissioner | B.S. | |
| Nevius, H. C..... | Deputy dairy commissioner | | B.S. | |

CONNECTICUT

*Connecticut Agricultural College, Storrs, Connecticut*

| | | | | |
|---|---|---|---|---|
| White, G. C..... | Professor | Professor of dairying | B.S., A.M. | 8 |
| Fisher, R. C..... | Professor | Associate professor of dairying | B.S., A.B. | 2 |
| Chapman, L. M..... | Assistant dairy husbandman | | B.S. | 3 |
| Campbell, P. A..... | | Dairy extension | B.S., A.M. | 1 |

DELAWARE

*Delaware College and Agricultural Experiment Station, Newark, Delaware*

| | | | | |
|---|---|---|---|---|
| Baker, T. A..... | Professor | | B.S. | 2 |
| Williams, Allan C.... | Instructor | | B.S. | 1 |
| Stretch, B. W..... | Stockman and instructor | | | 3 |

FLORIDA

*University of Florida, Gainesville, Florida*

| | | | | |
|---|---|---|---|---|
| Willoughby, C. H.... | Professor | Professor of animal husbandry and dairy husbandry | B.S. | 9 |
| Scott, John M..... | | Dairy extension | B.S. | 15 |

GEORGIA

*State University, Athens, Georgia*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Jarnagin, M. P..... | Professor | Professor of dairying and animal husbandry | B.S.A. | |
| Bennett, F. W..... | Associate professor | | B.S.A. | |
| Fitch, Frank W..... | Field agent in dairying | | B.S.A. | |
| Marlatt, Leo H..... | Specialist in cheese production | | | |

INDIANA

*Purdue University, Lafayette, Indiana*

| | | | | |
|---|---|---|---|---|
| Gregory, H. W..... | Professor | Chief of Dairying | M.S. | 4 |
| Fairchild, L. H..... | Assistant professor of dairying | | B.S. | 2 |
| Lucas, P. S..... | Assistant professor | | B.S. | 1 |
| Fleisher..... | Instructor | | B.S. | 1 |
| Leiendecker, E. H.... | Instructor | | B.S. | 1 |
| Spitzer, Geo..... | Associate in chemistry | | B.S. | 13 |
| Epple, Wm. F..... | Assistant in chemistry | | B.S. | 11 |
| George, C. R..... | Associate | Extension | B.S. | 6 |
| Canan, R. D..... | Assistant | Dairy extension | B.S. | 2 |

IOWA

*Iowa State College, Ames, Iowa*

| | | | | |
|---|---|---|---|---|
| Mortensen, M..... | Professor | Professor of dairying | B.S.A. | 12 |
| Hammer, B. W..... | Professor | | B.S.A. | 10 |
| Iverson, C. A..... | Assistant professor | | M.S. | 3 |
| Goss, E. F..... | Associate professor | | M.S. | 2 |
| Wenger, J. C..... | Instructor | | B.S. | 2 |
| Hinze, F. C..... | Instructor | | | 1 |
| Neasham, R. L..... | Instructor | | B.S. | 1 |
| Pearce, S. J..... | Instructor | | M.S. | |
| Cordes, W. A..... | Instructor | | M.S. | 2 |

KENTUCKY

*University of Kentucky, Lexington, Kentucky*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Hooper, J. J | Professor | | M.S.A. | 10 |
| Barkman, J. O | Instructor | | B.S. | 1 |
| Prewitt, E. M | | Extension | B.S. | 1 |
| Nutter, J. W | Superintendent of dairy | | | 15 |
| Mason, John G | Superintendent official testing | | B.S. | 1 |

LOUISIANA

*State University, Baton Rouge, Louisiana*

| | | | | |
|---|---|---|---|---|
| Cadwallader, J. M | Professor | Professor of dairying | | |
| Staples, C. H | | Dairy extension | | |
| Jefferson, E. C | Assistant | Dairy specialist | | |

MAINE

*University of Maine, Orono, Maine*

| | | | | |
|---|---|---|---|---|
| Corbett, L. S | Professor | Professor of dairying and animal industry | | 7 |
| Dorsey, L. M | Assistant | Dairy manufacturing | | 4 |

MARYLAND

*State College, College Park, Maryland*

| | | | | |
|---|---|---|---|---|
| Gamble, James A | Professor | Professor of dairying | M.S. | 2 |

MINNESOTA

*University Farm, St. Paul, Minnesota*

| | | | | |
|---|---|---|---|---|
| Eckles, C. H | Professor | Chief of division | M.S., D.Sc. | 2 |
| Palmer, L. S | Associate | Dairy chemist | Ph.D. | 2 |
| Keithley, J. R | Professor | Dairy products | M.S. | 1 |
| Fohrman, M. H | Assistant | Official tester | A.M. | 1 |
| Rayburn, A. B | Assistant | Dairy production | B.Sc. | 2 |
| Macy, H | Assistant | Dairy bacteriology | B.Sc. | 2 |

MICHIGAN

*Michigan Agricultural College, East Lansing, Michigan*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Burnett, J. E. | Associate | Dairying | M.S. | 5 |
| Goodwin, O. T. | Associate | Dairy manufacturing | B.S. | 2 |
| Riddell | Assistant | Research | B.S. | 7 |
| Howland, Arthur | | Field accountant | | 1 |
| Brownell | Assistant | Research | B.S. | 4 |
| Kurtz, Wm. J. | | Field accountant | B.S. | 2 |
| Hint, Elmer B. | Superintendent | Official testing | B.S. | 1 |
| Kellner, Hilda | Instructor | | | 1 |

MISSISSIPPI

*Mississippi Agricultural College, Agricultural College, Mississippi*

| | | | | |
|---|---|---|---|---|
| Moore, J. S. | Professor | Dairying | M.S. | 20 |
| Herzer, F. H. | Associate | Dairying | B.S. | 1 |
| Higgins, L. A. | | Dairy extension | B.S. | 5 |
| Brintnall, Earl | | Dairy investigator | B.S. | 1 |
| Ferguson, H. C. | | Dairy extension | B.S. | 1 |
| McGowan, W. G. | | Dairy extension | B.S. | 1 |
| Stone, H. C. | | Dairy herdsman | | |
| Crumpton, Dr. J. W. | Manager | Cooperative creamery | | |
| Nichols | | Buttermaker | B.S. | 1 |

MISSOURI

*University of Missouri, Columbia, Missouri*

| | | | | |
|---|---|---|---|---|
| Ragsdale, A. C. | Professor | Dairying | B.S. | 5 |
| Sweet, W. W. | Associate professor | | A.M. | 5 |
| Reid, Wm. H. E. | Assistant professor | | A.M. | 2 |
| Brody, S. | Assistant professor | | M.A. | 1 |
| Turner, Chas. W. | Instructor | | B.S. | 2 |
| Nelson, D. H. | Assistant | | B.S. | |

MONTANA

*University of Montana, Bozeman, Montana*

| | | | | |
|---|---|---|---|---|
| Martin, G. L. | Professor | | B.S.A. | 6 |
| Tomson, W. E. | | Extension | B.S.A. | 2 |

MASSACHUSETTS

*Agricultural College, Amherst, Massachusetts*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Lockwood, W. P. B... | Professor | Professor of dairying | M.Sc. | 12 |
| Judkins, H. F..... | Professor | | B.Sc. | 1 |
| Yaxis, T. G..... | Assistant professor | | M.Sc. | 1 |
| Upton, G. E..... | Instructor | | B.Sc. | 1 |
| Pendleton, H. F..... | Instructor | | B.Sc. | 7 mo. |
| Sheffield, A..... | | Superintendent of manufacturing | | 8 mo. |

NEW HAMPSHIRE

*Experiment Station, Durham, New Hampshire*

| | | | | |
|---|---|---|---|---|
| Fuller, J. M..... | Professor | Dairying | B.S. | 4 |
| Depew, H. F..... | Assistant professor | | B.S. | 3½ |
| Huggins, B. E..... | Instructor | | | 1½ |

NEW JERSEY

*Agricultural Experiment Station, New Brunswick, New Jersey*

| | | | | |
|---|---|---|---|---|
| Regan, William M.... | Professor | | M.S. | 3 |
| Button, Forrest C.... | Assistant professor | | B.S. | 2 |
| Mead, S. W..... | Assistant dairy husbandman | | M.S. | |
| Bartlett, John W..... | Extension specialist | | B.S. | 5 |
| Roberts, Stanley B... | Assistant dairy specialist | | | 1 |
| Robbers, Walter R... | Charge of official testing | | | 2 |

NEW MEXICO

*State College, State College, New Mexico*

| | | | | |
|---|---|---|---|---|
| Cunningham, Omar C. | Professor | | B.S.A. | 2 |

NEBRASKA

*University of Nebraska, Lincoln, Nebraska*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Hendrickson, J. W.... | Assistant professor | Dairy production and acting chairman | M.A. | 3 |
| Luithly, J. A..... | Assistant professor | Manufacturing | B.Sc. | 3 |
| Thompson, B. H..... | Assistant professor | Herd supervisor | B.Sc. | 4 |
| Lawritson, M. N..... | Assistant professor | Extension dairyman | B.Sc. | 2 |
| Boehr, J. W..... | Instructor | Official testing | M.Sc. | 1 |

NEVADA

*University of Nevada, Reno, Nevada*

| | | | | |
|---|---|---|---|---|
| Scott, V. E..... | Professor of dairying | | | |
| Nielson, C..... | Herdsman | | | |

NEW YORK

*Cornell University, Ithaca, New York*

| | | | | |
|---|---|---|---|---|
| Stocking, W. A..... | Professor | | B.S.A., M.S.A. | 14 |
| Ross, H. E..... | Professor | | B.S.A., M.S.A. | 14 |
| Troy, H. C..... | Professor | | B.S.A. | 8 |
| Guthrie, E. S..... | Professor | | B.A., Ph.D. | 12 |
| McInerney, T. J..... | Assistant professor | | B.S.A., M.S.A. | 10 |
| Jackson, H. C..... | Instructor | | B.S., M.S. | 5 |
| Downs, P. A..... | Instructor | | B.S. | 2 |
| Whiting, W. A..... | Instructor | | B.S. | 3 |
| Moon, M. P..... | Instructor | | A.M. | 2 |
| Neville, N. B..... | Instructor | | B.S. | 1 |
| Ayres, W. E..... | Extension instructor | | | 6 |
| Brew, J. D..... | Extension professor | | B.S. | 1 |
| Price, W. V..... | Assistant | | B.S. | 1 |
| Smith, L. E..... | Assistant | | | 1 |
| White, W. B..... | Assistant | | B.S. | |
| Perry, R. A..... | Instructor | | B.S. | 2 |
| Robinson, M. B..... | Assistant | | B.S. | 1 |

NORTH DAKOTA

*Agricultural College, Agricultural College, North Dakota*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Dice, James R..... | Professor | | A.M. | 1 |
| Rogers, George B.... | | Dairyman | B.S. | 1 |

OHIO

*State University, Columbus, Ohio*

| | | | | |
|---|---|---|---|---|
| Erf, Oscar..... | Professor | | B.S. | 13 |
| Stoltz, Robert B..... | Assistant professor | | B.S. | 9 |
| McKellip, Ivan..... | Professor | | M.S. | 6 |
| Drain, Harry D..... | Instructor | | B.S. | 1 |
| Kochheiser, Don..... | Instructor | | B.S. | 2 |

OKLAHOMA

*Agricultural Experiment Station, Stillwater, Oklahoma*

| | | | | |
|---|---|---|---|---|
| Baer, A. C..... | Professor | | B.S.A. | 4 |
| Burke, A. D..... | Assistant professor | | M.S. | 6 mo. |
| Doty, Harold E..... | | Foreman of dairy manufacturing | B.S. | 1 |
| Radway, C. W..... | | Extension dairyman | B.S. | 2 |

OREGON

*Oregon Agricultural College, Corvallis, Oregon*

| | | | | |
|---|---|---|---|---|
| Brandt, Phillip M.... | Professor | | M.S. | 3 |
| Chappell, Vincent D.. | Assistant professor | | M.S. | 3 |
| Jones, Roy C..... | Associate professor | | B.S.A. | 6 mo. |
| Colman, Howard N... | Instructor | | B.S.A. | 1 |
| Pine, William B..... | | | | 2 |
| Fitts, Edward B..... | Professor | Extension | | 6 |

PENNSYLVANIA

*Pennsylvania State College, State College, Pennsylvania*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Borland, A. A..... | Professor | Professor of dairying | M.S. | 6 |
| Bechdel, S. I..... | Associate professor | | M.S. | 8 |
| Hunter, C. A..... | Associate professor | | M.S. | 4 |
| Beam, A. L..... | Assistant professor | | M.S. | 6 |
| Combs, W. B..... | Assistant professor | | M.S. | 2 |
| Swope, W. D..... | Instructor | | B.S. | 2 |
| Mitten, J. W..... | Instructor | | B.S. | 5 |
| Kloser, M. M..... | Instructor | | B.S. | 2 |
| Knutsen, M. H..... | Instructor | | M.S. | 2 |
| Simpson, A. C..... | Instructor | | B.S. | 3 |
| Williams, P. S..... | Assistant instructor | | B.S. | 1 |

SOUTH CAROLINA

*Agricultural College, Clemson College, South Carolina*

| | | | | |
|---|---|---|---|---|
| Fitzpatrick, W. W.... | Professor | | B.S. | 4 |
| Cannon, L. B..... | Assistant professor | | B.S. | 3 |

SOUTH DAKOTA

*State College, Brookings, South Dakota*

| | | | | |
|---|---|---|---|---|
| Larsen, C..... | Professor | | M.S. | 14 |
| Wright, T. H., Jr.... | Assistant professor | | B.S. | 4 |
| Jones, Horace M..... | Instructor | | B.S. | 3 |
| Johnson, B. L..... | Analyst | | B.S. | 3 |
| Culhane, A. F..... | Instructor | | B.S. | 2 |

TENNESSEE

*College of Agriculture, Knoxville, Tennessee*

| | | | | |
|---|---|---|---|---|
| Wylie, C. E..... | Professor | | B.S.C., A.M. | 4 |
| Hutton, C. A..... | Dairy specialist extension | | B.Sc.A. | 6 |
| Clevenger, W. L..... | Dairy specialist manufacturing | | B.Sc.A. | 4 |
| Tobey, G. N..... | Cheese specialist | | | 4 |

TEXAS

*Agricultural College, College Station, Texas*

| NAME | RANK | DUTIES OR TITLE | DEGREES | YEARS IN POSITION |
|---|---|---|---|---|
| Pou, R. L | Professor | | | 1 |
| Clutter, J. A | Associate professor | | | 2 |
| Darnell, A. L | Associate professor | | | 8 mo. |

VERMONT*

*University of Vermont, Burlington, Vermont*

| | | | | |
|---|---|---|---|---|
| Ellenberger, H. B | Professor | | Ph.D. | 4 |
| Newlander, J. A | Instructor | | B.S. | 1 |
| Hitchcock, J. A | Extension dairy specialist | | B.S. | 6 mo. |
| *Jones, V. R | Instructor in butter | | M.S. | |
| *Bremer, H. E | Instructor in testing | | B.S. | |
| *Lynch, A. D | Instructor in butter | | M.S. | |
| *Frayer, J. M | Instructor in dairy husbandry | | B.S. | |
| *Gorman, George | Instructor in cheese | | | |
| *Dunning, R. G | Instructor in testing | | | |
| *Rand, S. A | Instructor in mechanics | | | |

WASHINGTON

*State College, Pullman, Washington*

| | | | | |
|---|---|---|---|---|
| Woodward, E. G | Professor | | A.M. | 3 |
| Phillips, C. A | Instructor | | B.S. | 1 |
| Martin, Fred S | Superintendent of official testing | | B.S. | 1 |

WEST VIRGINIA

*State University, Morgantown, West Virginia*

| | | | | |
|---|---|---|---|---|
| Anthony, Ernest L | Professor | | B.S.A., M.S. | 2 |
| Henderson, Harry O | Assistant professor | | B.S.A., M.S. | 1 |
| Perry, Enos J | Dairy extension specialist | | B.S. | 1 |

* The men indicated by the star are special instructors in dairy short courses only.

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